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Contents

In This Issue

The Economic Research Service, a faithful contributor to economic intelligence since 1961, is celebrating its 30th birthday this year. Congratulations, ERS, from the editors, board, and staff of the Journal.

The Bureau of Agricultural Economics created the Journal in 1949. In 1961, Willard Cochrane challenged the new agency, ERS, with his Journal article, "The Role of Economics and Statistics in USDA." Also, for this 1961 volume, Fred Waugh and Howard Davis wrote an article on the Food Stamp Plan; Bud Stanton on seasonal demand for beef, pork, and poultry; Tony Rojko on time series analyses; Fred Stocker on the urban fringe; and Ray Anderson on irrigation. There were notable others. The players have changed but the game goes on.

With this issue, the Journal ends a series of 10 essays by prominent agricultural economists and their distinguished allies on the condition of the agricultural economics industry and its products. These thoughtful essayists have ranged widely. They have been occasionally profound, sometimes provocative. But mostly they have written their essays as overviews, generalizations, or abstractions. In closing this series, the Journal provides a reminder that the agricultural economics industry consists not just of ideas, but of real people, like Karl Fox.

> "The role of economics in the Department of Agriculture is to make both basic and applied economic research a force for the betterment of all groups in our Nation and in the world."
> Willard Cochrane, *Agricultural Economic Research*, Vol. XIII, No. 3, July 1961.

Professor Fox reveals the growth and change of agricultural economics through his personal experiences. The development of his career over half a century took place in an environment of agricultural revolution, not only in production but in a transformation of rural society. Fox reflects these developments in the methods and theories employed in agricultural economics. His story is, to some degree, our story.

Thirty years ago, Fred Waugh and Howard Davis described food stamps, a welfare program for needy families, as "one of the most effective programs—dollar for dollar—for maintaining farm income." In this issue, Levedahl reports how converting the Food Stamp Program from stamps to cash will affect food expenditures. He found this conversion probably would result in a smaller decline in food purchases than was previously estimated. The predicted effect of such a conversion depends on the functional form of the equations estimating the marginal propensity to consume.

Tobey and Reinert used a general equilibrium model to show the effects of agricultural policy changes on environmental quality. They examined the Conservation Reserve and commodity price support programs, using selected chemicals and erosion as indicators of damage to environmental quality. Given the conditions specified in their scenarios, they claim an easing of acreage restrictions and reduced commodity price subsidies would produce an improved environment.

Nehring compares the effectiveness of input subsidies with commodity price supports as agricultural policies for Bangladesh. To encourage domestic production and reduce dependence on food grain imports, that government had provided fertilizer to producers at half the market price. Nehring reports, with customary qualification, that price supports are preferred to fertilizer subsidies for increasing output, at least in terms of reducing government costs and foreign exchange requirements.

We also include two short comments on data. The first comment, by Martin and Emami, demonstrates how choice of data can influence analysis. They illustrate their point with a Japan/United States trade model. The second comment, by Young, is an argument for making access to author's data a condition of article acceptance in a professional journal. The board and editors of JAER debated the issue actively, and concluded that although we encourage the open, free exchange of data, the problems of disclosure and preparation preclude such a policy for this Journal.

Book reviews: Crutchfield gives a qualified recommendation to read Braden and Lovejoy's set of nonmathematical papers, *Agriculture and Water Quality: International Perspectives*. Stier, with mixed feelings in his review, takes measure of Ellefson on *Forest Resource Economics and Policy Research*. Tobey examines still another composite of descriptive papers, *Public Policies and Environmental Protection*, edited by Portney and published by Resources for the Future. Leppert reviews a set of papers edited by Dahlberg, McLaughlin, and Niemann, *Developments in Land Information Management*.

As if to respond to the comments on data, Reinsel assesses a couple of purely data-oriented publications: Salant, *A Community Researcher's Guide to Rural Data*, and Frumkin, *Guide to Economic Indicators*. Following up on his article in this issue, Nehring

favorably reviews the Ahmed and Hossain book, *Developmental Impact of Rural Infrastructure in Bangladesh*. And, as if anyone reads policy history, Wunderlich reviews a fine book on Populism by Pollack, *The Humane Economy*.

So, happy birthday, Economic Research Service, thank you for your many years of support for the Journal, and may you continue to analyze interesting times.

Gene Wunderlich

A Career of Conceptualizing and Quantifying in Social Science

Karl A. Fox

This is the 30th anniversary of the establishment of the Economic Research Service, the 40th of my first article in *Agricultural Economics Research* (the earlier name of this journal), and the 50th of my enrollment in the graduate seminar which led me into agricultural economics.

Gene Wunderlich, the editor of this Journal, suggested that I address the role of agricultural economists in social science and the profession of knowledge building generally. I have been living this role with as much intensity as I could muster for almost 50 years. I will follow Gene's suggestion in terms of my own experience and leave most generalizations for my concluding remarks.

During 1942-54, I was a full-time member of the agricultural economics community. In it I found warm friendships, superb role models, and colleagues keenly interested in processes and institutions, open to useful ideas from several disciplines. I am not sure that any agricultural economist is "typical." So, my path through the profession should not be expected to represent the profession as a whole. Nevertheless, a "case study" does put real flesh on the abstract body of ideas called economics and social science. It also shows that the needs and opportunities for particular contributions to knowledge depend on the data systems, methods, and bodies of theory available at a given time and on current and anticipated conditions in the economy and society. The contributions of an individual depend on knowledge acquired before entering the profession and knowledge gained during its practice.

I acquired a superficial knowledge of the social sciences as a teenager, mainly because my father was a charter subscriber to the old *Encyclopaedia of the Social Sciences* (1930-35). I would leaf through each volume when it reached our home; the 15 volumes appeared at the rate of one every 4 months. I assumed then, as today, that all social sciences were equally relevant to our understanding of people in society.

Schooled in the traditions of several social sciences at the University of Utah, I completed an M.A. in sociology in 1938, then moved into general economics and completed my Ph.D. coursework and prelims at the University of California-Berkeley in that field. The most challenging job available when I was ready to take one was as an agricultural economist in the War Food Administration in San Francisco in 1942.

My career developed in the reverse sequence: 12 years in agricultural economics, 18 years largely in general economics, and 19 years working across the social sciences (including economics and agricultural economics). In all three phases, I emphasized visible, tangible, and measurable basic units and the integration of theory, methods, and data, traits I associate with agricultural economists.

A few special influences accompanied me to my first job. At Berkeley, in 1941, I had studied quantitative agricultural price analysis with George Kuznets and Harry Wellman and advanced economic statistics with A.H. Mowbray. The principal text in both courses was Mordecai Ezekiel's *Methods of Correlation Analysis* (1930), which was the pre-eminent book on applied regression analysis.[1]

Mowbray's course led me to Sewall Wright's 1921 article on "Correlation and Causation," which used arrow diagrams to state hypotheses concerning the causal relations connecting the various members of a system of variables. I followed Wright's example in my diagrams of the demand-supply-price structures for farm products, which figured prominently in my later work on demand analysis.

In Robert A. Gordon's seminar on business cycle analysis, I had given reports on Jan Tinbergen's *Statistical Testing of Business Cycle Theories* (1939) and Henry Schultz's *The Theory and Measurement of Demand* (1938), works that established the frontiers of macroeconometrics and microeconometrics for the next 15 years.

These courses and works placed heavy emphasis on applications. Schultz, Tinbergen, and Wright were reporting their own original research. Ezekiel was one of the most productive research workers in agricultural economics in the 1920's, and his book reflected this. In effect, all four were teaching by example from the initial conceptualization through the interpretation of results.

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Ideas and opinions expressed in this essay are those of the author and do not imply endorsement by the U.S. Department of Agriculture.

[1]Sources are cited in the Bibliography section at the end of this article.

A final influence was a good background in mathematics, according to the standards of the time, including advanced calculus and advanced differential equations as an undergraduate and mathematical theory of probability as a graduate student. With a little effort, I could figure out whatever demonstrations in economic or statistical theory seemed relevant to my applied work.

That first job in San Francisco was an exercise in applied common sense. Asked for analyses relevant to support and ceiling prices for many fruit and vegetable crops, my supervisor, Cruz Venstrom, and I launched a fast-moving but comprehensive project that: studied the apparent responses of acreages to prices for each crop in each county; examined research reports on farm enterprise costs and yields; checked with California State statisticians to be sure we were interpreting their county average price series correctly; and surveyed experienced growers who were temporarily working for the regional office.

In each case, we selected a set of variables which we thought had accounted for most of the changes in acreage planted to a particular crop in a particular county. If two crops competed for land in a given county, their acreages were jointly determined. Our methods were informal, but we gradually built up a system of prices for many crops that we thought would have maintained their acreages at nearly constant levels during 1935-39. They provided the starting points for approximate adjustments to the cost levels projected for 1943, enabling us to handle requests for advice on different crops in a consistent manner.

In August 1944, I transferred to the regional office of USDA's Bureau of Agricultural Economics (BAE) in Berkeley to work 6 months with Marion Clawson, one of the best rough-and-ready economic analysts I ever met and a forthright and vigorous leader. Clawson had directed studies of the probable economic impacts of the Columbia Basin hydroelectric power and irrigation project in the Pacific Northwest and was coordinating similar studies of the Central Valley Project in California.

My first task was to draft a report on the prospective impacts of the Central Valley Project on industrial locations in California. Fortunately, the National Resources Planning Board had just published an outstanding report, *Industrial Location and National Resources* (1942), a good introduction to a field later known as regional economics. Mostly, I applied P. Sargant Florence's concepts of resource-oriented, consumer-oriented, and footloose industries to California data. Concepts of the economic base (including agriculture, which would expand with increased supplies of irrigation water) and an employment multiplier were at least implicit in Florence's approach and my application. Abundant supplies of electric power at projected low prices were also considered as a factor in attracting new industries.

Next stop was the Washington headquarters of BAE and work with its Chief, the brilliant and incisive O.V. Wells. Not long ago I heard Harold Breimyer refer to him as "the man with the trip-hammer mind." Breimyer had known him since the 1930's and regarded him as the principal (though anonymous) author of the Soil Conservation and Domestic Allotment Act, which salvaged and redirected the farm price support program after the original Agricultural Adjustment Act had been overturned by the Supreme Court.

During 1945-50, Wells used me on a series of urgent special assignments, each of which required me to collate and interpret forecasts of demands and supplies for farm products comprising most of the agricultural sector. The specific forecasts were usually made by commodity specialists in BAE's Division of Statistical and Historical Research (S and HR), but as time went on I examined most of the formal and informal analyses on which their forecasts were based. The analyses were of varying quality, but there were no resources for improving the weaker ones.

The special assignments included 3 months (April-June 1945) as economist for the House Special Committee to Investigate Food Shortages, which held hearings and issued reports on the demand, supply, price control, and rationing situations for sugar, food fats and oils, and meat, poultry, and fish. Black markets were widespread and marketing channels distorted. It was a rare opportunity to observe demand and supply systems under pathological stress.

When the Marshall Plan for European economic recovery and development was proposed in June 1947, I assembled USDA estimates of the U.S. capacity to export specified agricultural products in support of the plan. As secretary of the Food Resources Subcommittee of the President's Committee on Foreign Aid, I worked with other secretaries to appraise the capacities of all relevant sectors of the U.S. economy and to prepare materials for the committee's consideration.

Also during 1947-48, I coordinated and edited a USDA report to the House Agriculture Committee on long-range prospects for American agriculture. During 1949-50, I helped coordinate an internal USDA study of the probable costs and consequences of alternative price support programs over a period of years under three different economic scenarios; the study was left incomplete when USDA's concerns shifted to shortages and inflation rather than surpluses and price supports in June 1950 with the outbreak of hostilities in Korea.

In the fall of 1950, I took stock of my professional situation. For several years I had been busy and happy with the special assignments which brought me approval and promotions from Wells and prestige among my colleagues in BAE. But I had published only one journal article and I had not submitted a dissertation to Berkeley.

I thought I could make an important contribution to demand analysis for farm and food products. I had internalized an enormous amount of information about the food and agricultural sector, read a large proportion of the published literature on demand analysis, and acquired up-to-date training in economic theory and econometrics.

The last coordinated set of demand studies by BAE economists had been published in the 1920's and early 1930's. Since then, BAE's data systems on food consumption and farm-to-retail price spreads had been greatly improved, as had the Commerce Department's data on disposable personal income. Some problems associated with multiple regression analysis of time series (multicollinearity, autocorrelation, the interpretation of significance tests) had been substantially clarified. And, there were now 20 years of data (1922-41) undisturbed by the special circumstances of World Wars I and II and their immediate aftermaths.

A consistent set of demand analyses for many farm and food products would be of value to S and HR commodity specialists in their economic outlook work and in their responses to requests for sectorwide projections and price-support program analyses, which were bound to recur. It might also be of interest to the profession as a whole.

During November-March 1950-51, I worked directly with S and HR's excellent commodity clerks and outstanding Computing Pool. The first result was an article, "Factors Affecting Farm Income, Farm Prices and Food Consumption" (1951a), which included about 70 statistically estimated equations. (Other Karl Fox publications are listed in "A Career in Print" in this essay.)

The second result was a dissertation submitted to Berkeley in 1952, "The Demand for Farm Products," a condensed version of which was published by USDA as *The Analysis of Demand for Farm Products* (1953a). Both included arrow diagrams of the demand and price structure for major livestock products and for five categories of crops. The identification problem posed by Haavelmo in 1943-44 was carefully considered. I demonstrated that the demand functions for many foods and farm products could be estimated without bias by ordinary least squares. I also showed that the demand functions for other commodities had to be estimated by simultaneous equation methods, for which I had neither time nor computing resources. These demonstrations formed the basis for my article on "Structural Analysis and the Measurement of Demand for Farm Products" (1954b).

From 1951 on, I carried in my mind a sort of econometric map of the agricultural economy, based on my arrow diagrams, empirical estimates of many of their components, and estimates of other analysts. I could easily visualize elaborations of this national map to include demand and supply curves for specific commodities in each member of a set of regions. The existence of interregional trade in a given commodity would imply that prices in shipping and receiving regions would differ because of transportation costs. Quantitative models of interregional trade might permit S and HR specialists to regionalize their outlook statements for certain commodities.

I explored this idea in "A Spatial Equilibrium Model of the Livestock-Feed Economy in the United States" (1953b). The model involved a demand function for feed and a predetermined supply of feed in each of 10 regions, plus a matrix of transport costs between regions. It proved easy to solve and explain without using the formal methods and jargon of quadratic programming, and the model revealed important insights into a system accounting for more than half of all cash receipts from marketings of farm products. "The Use of Economic Models in Appraising Foreign Trade Policies" (1954a) adapted the 10-region model to explore the effects of general and discriminatory tariffs, subsidies, and changes in transport costs on prices, consumption, and trade in a hypothetical 10-country world. In this context, the spatial equilibrium approach also clarified some important issues.

In 1951, I decided to put on record in "The Measurement of Price Support Costs" (1951b), the logical and mathematical framework of the 1949-50 study of price support programs previously mentioned. A May 1954 conference on Policies to Combat Depression led to my semi-empirical paper on "The Contribution of Farm Price Support Programs to General Economic Stability" (1956a), which followed the outlines of the 1949-50 study and also provided for agricultural feedback to the nonfarm economy. In effect, I combined a detailed model of the agricultural sector with a highly aggregated model of the nonfarm economy.

In 1955, Klein and Goldberger published a 20-equation model of the United States. In reviewing it in "Econometric Models of the United States" (1956b), I pointed out that the model's chief limitation was its high level of aggregation, much too high to accommodate significant information about particular sectors of the economy, such as agriculture, and to tap the knowledge and judgments of sector specialists. I observed that "our knowledge of the agricultural sector is adequate to support an econometric model of considerable complexity," including demand and sup-

A Career in Print

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ply functions for 20 to 25 major commodities or groups, and that such a model would be highly useful for policy purposes. A truly large-scale dynamic model of the U.S. economy would permit the advance appraisal of any set of economic policies and programs in relation to any initial positions and trends of the various sectors of the economy.

I never left the BAE, the BAE left me. Pieces of the former BAE were absorbed into new agencies in 1953-54. My position, absorbed into the Agricultural Marketing Service, involved a promotion and more administration than I cared for, so I joined the staff of the Council of Economic Advisers in 1954 and then moved to Iowa State University in 1955.

At Iowa State, research on commercial agriculture had been going well without my help. However, I found that a good many people in Iowa were concerned about the decline of small towns and the weakening of rural institutions. Some agricultural economists recognized that the seemingly inexorable process of farm enlargement was reducing the farm population and hurting small towns, but they were not paid to think about such things. State extension economists and sociologists handled individual requests originating in one or another of Iowa's 99 counties. The larger picture was ignored. Who would be foolish enough to produce an answer for which there was no question?

During 1955-60, pressure from concerned Iowans on university administrators brought more focused attention to problems of "agricultural adjustment." In 1961, the Kennedy administration responded to similar pressure at the national level and provided funds to the land-grant universities for programs of rural develop-

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ment which could involve areas larger than counties. Extension Service administrators at Iowa State asked me to suggest criteria for delineating such areas.

Studies by rural sociologists before World War I indicated that the residents of a small town and its trade area formed a relatively self-contained community. The boundary of the trade area was about five road-miles from the town or an hour's travel time with horse-drawn vehicles. The automobile had changed the face of rural America. When workers in Iowa began daily commutes in 1961, most of them headed for central business and industrial districts of Iowa's larger cities.

My research showed that a relatively self-contained community could be delineated around 11 or 12 Iowa cities, each of which was a wholesale trade center with a population of 25,000 or more. Each such city had a large number of jobs in a wide range of occupations and was the center of a labor market area, a home-to-work commuting area with a radius of about 50 road-miles and extending over several counties. I later called such areas FEA's, functional economic areas.

The trade and attendance areas for retail stores, schools, churches, and other voluntary associations were usually much smaller than an FEA. Most of the wages and salaries paid out by employers in an FEA would be spent at establishments within its boundaries, making it relatively easy to create FEA income and product accounts compatible with national economic accounts. The resident population of an FEA would also spend nearly all of its time within its boundaries during a given year.

The FEA delineations were used for several purposes in Iowa and the concept was rapidly disseminated across the United States. The Census Bureau commissioned a study by Brian J.L. Berry at the University of Chicago which delineated 358 FEA's, containing 96 percent of the U.S. population.

The FEA concept was endorsed by a committee of the Social Science Research Council on (Geographic) Areas for Social and Economic Statistics in 1967. A national system of FEA's comprised of clusters of contiguous whole counties could accommodate the county data bases of several agencies: the Standard Metropolitan Statistical Areas (SMSA's), which contained the central cities of the more populous FEA's; the additional counties within commuting distance of each SMSA; and the many nonmetropolitan FEA's centered on cities of less than 50,000 people. The Commerce Department's Bureau of Economic Analysis used the FEA's as a starting point for its system of BEA Economic Areas, which was used for regional economic projections by several U.S. agencies and by the National Planning Association.

During my tenure as a department head at Iowa State, I was fortunate to recruit some outstanding young economists. Two of them, Erik Thorbecke and Jati Sengupta, shared my admiration for Jan Tinbergen and were particularly enthusiastic about his 1952 book, *On the Theory of Economic Policy*. According to Tinbergen, a policymaker should classify the variables in a national econometric model as (1) targets, (2) instruments, (3) noncontrollable, and (4) irrelevant in relation to the array of policies under consideration at a particular time.

Desired values of the target variables in the coming year (for example, employment, income, and balance of payments) might be chosen intuitively, but in principle they (and some or all of the instruments) could be included in an objective function reflecting the policymaker's value system. Tinbergen emphasized the implications of a specified set of target values however chosen. Henri Theil, in his *Economic Forecasts and Policy* (1958), worked out the formal implications of an objective function. Theil's version of the "steering problem" had strong affinities with stochastic control theory.

Sengupta was well versed in quantitative economics and operations research, including stochastic control theory; Thorbecke was specializing in economic development. I joined them in coauthoring a book, *The Theory of Quantitative Economic Policy* (1966), which made major extensions and applications of the Tinbergen and Theil approaches to economic growth and stabilization models and regional and sectoral analyses.

I extended my earlier conceptualizations in "The Study of Interactions Between Agriculture and the Nonfarm Economy—Local, Regional and National" (1962) and "Spatial Price Equilibrium and Process Analysis in the Food and Agricultural Sector" (1963). My most detailed conceptualization of the food and agricultural sectors of the United States and other large countries or multicountry regions was realized in 1969 in "Toward a Policy Model of World Economic Development with Special Attention to the Agricultural Sector." Regions classified according to soil and climate intersect with functional economic areas. Spatial equilibrium models are suggested both within and among 20 large world regions. In addition, concepts from several social sciences are introduced as relevant to the description and analysis of systems of villages, towns, and cities.

My work on FEA's had put me in touch with some outstanding urban and regional economists and quantitative geographers, and my membership on the Board of Directors of the Social Science Research Council (1963-67) involved semi-annual meetings with leading social scientists from several disciplines. These contacts stimulated me to read some of the best books published by social scientists in the 1950's and 1960's—the best disciplinary research, in Glenn Johnson's terminology.

The social indicators movement was launched in 1966 with impressive essays by outstanding scholars. Their immediate objective was to create a Council of Social Advisers (parallel to the Council of Economic Advisers), which would spearhead rapid development of data systems adequate for the guidance and evaluation of the many social programs initiated by the Johnson administration. A yearly *Social Report of the President* would appraise social conditions and recommend policy adjustments; a statistical appendix would present the relevant data.

This objective was not realized, but a demand for social indicators had been created and some highly eclectic work was published by people with little or no training in the social sciences. There was an enormous gap between social indicators and social theory, and I thought I could make an important contribution toward closing, or at least narrowing, it.

During 1972-73, a National Science Foundation (NSF) grant enabled me to spend 14 months on full-time research. By March 1973, I was ready to describe a framework which I thought would accommodate observable units and measurements from several social sciences, including economics. The framework would accommodate commercial agriculture and rural communities along with all other sectors and elements of an economy and society. The result: *Social Indicators and Social Theory: Elements of an Operational System* (1974), which advocated the supplementation, and eventual partial replacement, of social indicators by social accounts.

Elements of an operational system were designated at three levels: (1) individuals, families, and organizations in a small community; (2) cities and regions; and (3) national and world models and data. Subjectively, I felt I had written the book in the tradition of agricultural economics and dedicated it to Mordecai Ezekiel and Frederick V. Waugh, pioneers in combining measurement with theory.

While writing *Social Indicators and Social Theory*, I decided that "behavior settings," as defined by the psychologist Roger Barker of the University of Kansas, were promising basic units for a system of social accounts which would accommodate variables of interest to all of the social sciences. To implement such a system, we would need a criterion of comprehensiveness (what range of human activities should be included?); an objective method of classification that applied equally to market and nonmarket activities; and an objective unit for sampling and recording the contributions (inputs) people made to the social system and the rewards (outputs) they received from it.

I thought we could meet these requirements by viewing human societies from the perspective of "eco-behavioral science," a term introduced by Barker in 1969 after 22 years of pathbreaking research within a somewhat narrower framework which he called "ecological psychology"—the study of individual behavior in the settings of everyday life.

While observing children in a small Kansas town, Barker noted that their behaviors changed abruptly when they moved from one setting to another; these settings were units of the children's environment. Third-grade academic subjects called for one pattern of behavior, hallways for another, and lunchrooms for a third. Adults changed their behaviors abruptly as they moved from offices onto the town's streets and sidewalks and into restaurants, barbershops, or grocery stores. He concluded that the town, as an environment for human behavior, was *de facto* partitioned into hundreds of distinct observable units which he called behavior settings.

In various contexts, Barker and his colleagues asserted that "a school *is* its behavior settings" or "a community *is* its behavior settings." One colleague, Paul Gump, stated: "People live out their lives in a series of environmental units (behavior settings); experience in these settings *is* life. If experience is good, life expands; if it is bad, life diminishes." The study of behavior settings, and of organizations and communities viewed as systems of behavior settings, is called eco-behavioral science.

Barker and his associates made several comprehensive surveys of the behavior settings of a Kansas town. My 1990 book, *The Eco-Behavioral Approach to Surveys and Social Accounts for Rural Communities*, provides a detailed introduction to the method of behavior setting surveys and the microdata of Barker's last and most advanced survey. The book sets forth proposed applications and needs for multidisciplinary cooperation, highlighting the advantages of rural social scientists, including agricultural economists, in eco-behavioral research.

My 1985 book, *Social System Accounts: Linking Social and Economic Indicators through Tangible Behavior Settings*, and my 1989 article, "Behavior Settings and Social Systems Accounting," summarize my ideas for relating behavior settings to official data systems on establishments, industries, occupations, employment, and earnings; to the Standard Industrial and Standard Occupational Classifications; to Commerce Department data on stocks of various types of physical capital and consumer durable goods; to studies of time use; and to the objective social indicators published since 1982 by the Organization for Economic Cooperation and Development (OECD).

Agricultural economists are engaged in a remarkably wide range of activities. Many of us have cooperated with applied scientists and engineers in problem solving and subject matter research. Neither we nor they have felt obligated to uphold disciplinary purity at all costs. I have seen cooperation in the same spirit between agricultural economists and rural sociologists.

I don't know how other agricultural economists feel about our relationship to "general" economics. If we are strictly in an area of application of economic theory, then perhaps we should not make room in our graduate programs for other kinds of theory. However, in our preface to *Systems Economics* (1987), Don Miles and I asserted that "the most promising frameworks for multidisciplinary cooperation can be expressed in the language of general systems theory, broadly conceived" (p. ix). We suggest that this book of essays by nine economists might be used as a guide for new and experimental courses in "systems economics" or "systems approaches to multidisciplinary research." Students may choose additional readings from references cited in the various essays.

I have emphasized social accounts for particular cross-sections of time since 1973. However, social accounts for successive years or quarters over a period of time would provide bases for dynamic models of macrosocial systems at national and regional levels. Some important conceptual work has been done toward dynamic models of microsocial systems based on behavior settings; these are annotated in pages 355-73 of *The Eco-Behavioral Approach to Surveys and Social Accounts for Rural Communities* (1990). Notable contributions include James R. Prescott's chapter, "A Behavior Setting Approach to Microanalytical Simulation Models at the Community Level," in *Social System Accounts* (1985) and a related chapter by Prescott in *Systems Economics* (1987); Allan W. Wicker's article,

"Behavior Settings Reconsidered: Temporal Stages, Resources, Internal Dynamics, Context" in *Handbook of Environmental Psychology* (1987); and Jati K. Sengupta's article, "Modeling Eco-Behavioral Systems," in *Mathematical Social Sciences*, Vol. 11 (1986).

My path through agricultural economics, economics, and social science has been a long one. In agricultural economics, my role models were Mordecai Ezekiel, O.V. Wells, and Fred Waugh; in economics, Jan Tinbergen; in quantitative methods, Sewall Wright and Herman Wold; in social science, Herbert Simon and Kenneth Boulding; in social accounting and model-building, Richard Stone; in eco-behavioral science, Roger Barker.

I felt a strong sense of community in agricultural economics during 1942-54, and I enjoyed warm relations among general economists during the 1960's. After 1971, my preoccupation with social system accounts and eco-behavioral science left me pretty much isolated from both communities, though not from particular colleagues who shared my new interests.

If I had remained continuously involved with agricultural economists, I might have realized that their concerns had broadened tremendously. My participation in a 1988 workshop sponsored by the Social Science Agricultural Agenda Project woke me up, but like Rip Van Winkle, I was not able to contribute much to the brave new world.

I have been greatly impressed by the accomplishments of my near-contemporaries—Glenn Johnson, James Bonnen, Harold Breimyer, and Vernon Ruttan, among others. The performance of some younger members of the profession marks them as worthy successors to Ezekiel, Wells, and Waugh. I believe the profession is well-equipped to generate new knowledge relevant to the enormously complicated economic, social, political, and environmental problems in which we are now immersed.

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The Role of Functional Form in Estimating the Effect of a Cash-Only Food Stamp Program

J. William Levedahl

Abstract. *Larger marginal impacts on household food spending come from food stamps than from equivalent cash income, according to previous studies. These studies have been limited, however, in using food expenditure equations that are linear in the coefficients, placing prior constraints on the estimated marginal propensities to spend (MPS) from cash and from stamps. This article re-examines the earlier MPS estimates in light of a more general and flexible food expenditure equation, comparing estimates from a common data set under alternative functional forms. The article estimates changes in food spending that would result under each functional form from "cashing out" food stamps, and replacing stamps with equivalent cash benefits. Results show that: MPS estimates vary widely depending on functional form; past estimates tended to substantially exaggerate the cash-out effect in reducing food spending; and the most general, consistent, and flexible forms show a 10-cent reduction in food spending for each dollar of food-stamp benefit shifted to a cash payment.*

Keywords. *Food expenditures, food stamps, Nationwide Food Consumption Survey, poverty.*

The conceptual basis of the relationship between food stamps and food expenditures was initially presented by Southworth. In his formulation, the marginal propensities to spend (MPS) out of food stamps and out of income are equal whenever food expenditures exceed food stamp benefits. Empirical estimates have shown consistently that, for food bought for consumption at home, the MPS out of food stamps is several times greater than the MPS out of income (*13*).[1] All previous estimates of the MPS's have been obtained with food expenditures equations that are linear in the coefficients.

Not all evidence, however, indicates unequal MPS's. When Puerto Rico initiated a cash-only program in 1982, no measurable reduction in food expenditures occurred (*4*). A 1982-83 USDA demonstration project involving the elderly found that a cash-only program had little effect on food expenditures (*1*). These exceptions suggest that additional research is needed to reconcile the differences. In fact, the Food and Nutrition Service (FNS) is currently conducting demonstration projects in San Diego and in parts of Washington State and Alabama to measure the impact on household food expenditures of turning food stamp benefits into cash payments.

The principal finding of this article is that the choice of a functional form of the food expenditure equation greatly influences estimates of the MPS's and estimates of the change in food expenditures resulting from a cash-only food stamp program (FSP).

The Food Expenditure Equation

The household is assumed to maximize its capacity with respect to food consumed at home, food consumed away from home, and a composite of all other goods subject to income and food stamp constraints. Denote this by:

$$\max L = U(F,S,A,X) + g_1(Y - p_f F - p_a A - p_x X) + g_2(Y_s - p_f S), \qquad (1)$$

where F, S are food purchased for at-home consumption using income and food stamps, respectively;

A is food purchased for away-from-home consumption;

X is a composite of all other goods;

p_f, p_a are the prices for food at home and away from home, respectively;

p_x is the price of other goods;

Y is money income;

Y_s is the food stamp benefits; and

g_1, g_2 are Lagrangian multipliers.

L is maximized with respect to the variables F, S, A, X, g_1, and g_2 given Y_s, Y, p_f, p_a, and p_x. Note that the utility of food bought with stamps and the utility of food bought with income need not be the same. When all stamps are used, $g_2>0$. But, $g_2=0$ if all food stamps are not used and no food purchases are made out of income. Only households whose food expenditures exceed the value of their food stamps ($g_2>0$) are considered.

Solving equation 1 and substituting the optimal values back into this equation gives:

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

$$\underline{L} = U(\underline{F},\underline{S},\underline{A},\underline{X}) + g_1(Y - p_f\underline{F} - p_a\underline{A} - p_x\underline{X}) + g_2(Y_s - p_f\underline{S}), \quad (2)$$

where the underlining denotes optimal values and $g_1 \geq g_2 > 0$. The demand function for at-home food purchased with income can be defined using equation 2 and the envelope theorem. The total differentials of the objective function with respect to changes in Y, p_f, and Y_s are:

$$d\underline{L}/dY = g_1,$$

$$d\underline{L}/dp_f = -\underline{f}_1\underline{F} - \underline{g}_2\underline{S}, \text{ and}$$

$$d\underline{L}/dY_s = \underline{g}_2.$$

Rearranging terms gives the demand function for at-home food purchased with income as:

$$\underline{F} = -(1/\underline{g}_1)[d\underline{L}/dp_f + \underline{Sg}_2]. \quad (3)$$

For households receiving food stamps, this equation is a generalization of Roy's identity (*16*, pp. 126-27).

Define demand for food at home as $\underline{D} = -(d\underline{L}/dp_f)/\underline{g}_1$ and rewrite equation 3 as:

$$\underline{F} = \underline{D} - (\underline{g}_2/\underline{g}_1)(Y_s/p_f). \quad (4)$$

The ratio $\underline{g}_2/\underline{g}_1$ is the household's marginal evaluation of food bought with food stamps relative to food bought with income. This ratio equals 1 in the Southworth model, implying that the marginal utility of food bought with either income or food stamps is equal. Equation 4 implies that Y_s (food stamps) are equivalent to the quantity $(\underline{g}_2/\underline{g}_1)(Y_s/p_f)$ of food bought with income. This quantity, previously bought with income, will be bought using food stamps. The more similar the marginal utilities of the food bought with food stamps and with income, the greater the substitution of income in the purchase of food.

At-home food expenditures from all sources are obtained by multiplying equation 4 by the price of food and adding Y_s to both sides:

$$\underline{E} = p_f\underline{D} + (1 - \underline{g}_2/\underline{g}_1)Y_s. \quad (5)$$

The fraction $(1 - \underline{g}_2/\underline{g}_1)$ is the proportion of Y_s that results in new food expenditures for a given level of at-home food demand.

The demand for food away from home is derived in the same manner used for deriving the demand for food at home. Adding the resulting demand for food away from home to the demand for food at home gives the total demand for food purchased with income:

$$\underline{F} + \underline{A} = -(1/\underline{g}_1)[d\underline{L}/dp_f + \underline{Sg}_2 + d\underline{L}/dp_a]. \quad (6)$$

Table 1—Expenditure equation, by functional form and implied ratio of MPS's

Functional form[1]	MPS(Y_s)/MPS(Y)
Linear-in-the coefficients specification:	
Linear—	
$E = a + bY + cY_s$	c/b
Semi-log—[2]	
$E = a + b\ln(Y) + cY_s$	$(c/b) \cdot Y$
Double-log—[2,3]	
$\ln(E) = a + b\ln(Y) + cY_s/Y$	$(b/c - Y_s/Y)^{-1}$
Translog specifications[1]	
Defined in equations 11 and 12	$\dfrac{1 + (Y/Y_s)(1/eh_2)[(1\text{-}w)SA1 - 1\ a_{134}]}{w + (1/eh_2)[w(SA3+SA4) - (1\text{-}w)(SA1+SA2)]}$

[1]E is expenditures and w is the appropriate share of money income.

[2]The versions of the semi-log used by Neenan and Davis and the double-log used by Senauer and Young were specified so that the expenditure equation of the nonparticipants could be estimated with the participants. However, previous studies have found no sample selection bias between the two groups (*4*, *12*).

[3]This version is called the double-log because it can be written $\ln(E)=a + b\ln(Y) + \ln(1+cY_s/Y)$ using the approximation $\ln(1+a)=a$ providing $|a| \leq 1$.

Total spending on food, therefore, is:

$$\underline{TE} = p_f\underline{D} + p_a\underline{A} + (1 - \underline{g}_2/\underline{g}_1)Y_s.$$

Estimates of the Marginal Propensities to Spend

Previous estimates of the MPS's have been obtained using food expenditure equations that are linear in the coefficients. Table 1 illustrates the three versions previously used. The most common has been the linear version (*2*, *7*, *10*, *12*, *14*). In some cases, variables measuring an interaction between income or food stamps and other determinants have been included. Besides the linear version, a semi-log linear version (*17*) has been used, as well as a double-log version (*13*).[2]

Specification of the Food Expenditure Equation

Few reasons are given for choosing specifications that are linear in the coefficients other than convenience in estimation. However, there are reasons for not choosing them. For one, all known theoretically consistent systems of consumer demand functions of three or more commodities that are linear in the coefficients have the property of unitary income elasticity for all commodities (*8*). Choosing a food expenditure equation that was based on a theoretically consistent system of consumer demand, therefore, would eliminate specifications that are linear in the coefficients.

[2]Versions of the semi-log and double-log have been defined to avoid including $\log(Y_s)$ for nonrecipients. However, this article considers only food stamp recipients. The food expenditure specifications used by Huang, Fletcher, and Raunikar and by Senauer and Young are within a Tobit model.

A second reason for avoiding specifications that are linear in the coefficients is the prior restrictions these specifications place on the MPS's. These specifications are not flexible enough to estimate all theoretically consistent MPS's. The inflexibility can be illustrated for the MPS out of food stamps. For at-home food expenditures, the theoretically consistent expression for $MPS(Y_s)$ from equation 4 is:

$$MPS(Y_s) = 1 - p_f \delta D/\delta Y_s - \underline{g}_2/\underline{g}_1(1 - \epsilon) \geq 0, \quad (7)$$

where ϵ is the elasticity of $\underline{g}_2/\underline{g}_1$ with respect to Y_s. The $MPS(Y_s)$ is measured relative to 1 since, by assumption, recipient households spend all their food stamps. The second term in equation 7 represents the change in food expenditures that results from the change in total at-home food demand when food stamps change. The third term represents the change in food spending that results from a relative change in the marginal value of food bought with food stamps compared with income.

Both the linear and semi-log linear versions specify $MPS(Y_s)$ as constant. Such a parameterization provides a poor approximation to equation 7 since it requires that no change occur in the marginal value of food bought with food stamps relative to income and that a change in food stamp benefits leave total at-home food demand unchanged.

In the double-log version, $MPS(Y_s) = cw$ for scalar $c \geq 0$ and the food expenditure share $w = E/Y$. If the share of food declines (from whatever source), then the marginal propensity to spend out of food stamps falls. Equation 7 shows this decline can occur in one of two ways: each food stamp stimulates less total at-home food demand, or each food stamp replaces a greater amount of food bought with income.

A decline in the food share, however, is consistent with food stamps replacing a smaller, rather than a larger, amount of food bought with income. A declining share is also consistent with an increase in the marginal utility of food at home relative to other goods. In both cases, a declining share would be consistent with an increase in the $MPS(Y_s)$, a result at variance with the parameterization of $MPS(Y_s)$ in the double-log version. The actual response of $MPS(Y_s)$ to a change in an exogenous determinant depends on how food bought using income substitutes compared with food bought using food stamps and with all other goods.

My choice of the food expenditure equation in this article was based on a desire for a theoretically consistent and flexible equation. Compared with the specifications that are linear in the coefficients, flexible functional forms impose fewer prior restrictions on the MPS's, and, therefore, can be used to judge how well the specifications that are linear in the coefficients fit the data. A theoretically consistent expenditure equation also provides coefficient restrictions.

I used the translog indirect utility function to derive a flexible expenditure function:

$$I(Y_s, Y, p_f, p_a, p_x, Z) = -a_o - F(Z) - \ln x'a$$
$$-(1/2)\ln x'A\ln x - \ln x'DZ, \quad (8)$$

where F depends on Z, a $k \times 1$ vector of household attributes,

$$\ln x' = [\ln(Y_s/Y)\ \ln(p_f/Y)\ \ln(p_a/Y)\ \ln(p_x/Y)], \text{ and}$$
$$= [\ln x_1\ \ln x_2\ \ln x_3\ \ln x_4].$$

a_o is a scalar, a is a 4×1 vector, $A = (a_{ij})$ is a 4×4 symmetric matrix, and D is a $4 \times k$ matrix of coefficients corresponding to commodity-specific demographic effects.

Using the generalized version of Roy's identity (equation 3) and the indirect utility function (equation 8), I determined the demand for food at home purchased with cash. Substituting this expression into the identity $E \equiv p_f F - Y_s$ gives an expenditure equation that is consistent with utility maximization and is flexible:

$$E = Y(h_1/h_2) - Y_s, \quad (9)$$

where

$$h_1 = a_1 + a_2 + \sum_j (a_{1j} + a_{2j}) \ln x_j + (D_1\ D_2)Z, \text{ and}$$

$$h_2 = \sum_i a_i + \sum_i \sum_j a_{ij} \ln x_j + (D_1\ D_2\ D_{pa}\ D_{px})Z.$$

The corresponding equation for total food expenditure is:

$$TE = Y(t_1/t_2) - Y_s, \quad (10)$$

where

$$t_1 = a_1 + a_2 + a_3 + \sum (a_{1j} + a_{2j} + a_{3j}) \ln x_j + (D_1\ D_2\ D_{pa})Z,$$

and

$$t_2 = h_2.$$

Empirical Results

I used the ratio of the MPS's to measure the difference between the MPS's out of food stamps and out of income. The ratio is a better measure than, say, the difference between the MPS's because it captures the correlation between the two MPS's that might exist across households. This correlation is important because it tells how households adjust their food expenditures in response to changes in food stamps

and income. The correlation also implies that the mean ratio of the MPS's is the preferred measure compared with, say, the ratio of the mean MPS's.[3]

Data from the 1979-80 Nationwide Food Consumption Survey, Low Income Sample (NFCS-LI) were used to estimate the expenditure equations. This survey was administered after the elimination of the food stamp purchase requirement.[4] In this article, only those households that received food stamps and whose expenditures on food for at-home consumption exceeded the value of their food stamps were used. Households were deleted if their food expenditures in excess of food stamp benefits were greater than their average monthly income. In all, 1,210 households were included in the estimating sample.[5]

Information on household characteristics and food use came from a personal interview of the household member most responsible for food planning and preparation. The member was contacted at least 1 week before the interview and asked to keep notes on food use and costs. Prompts were used to aid recall during the interview. The recall data on the total money value of purchased food used in the last 7 days (less alcoholic beverages) is the basis of the food expenditures variable. The weekly expenditure figure was adjusted to a monthly basis to conform with the other variables. The money value of both alcoholic beverages and food not purchased is excluded from the analysis since they cannot, in principle, be purchased with stamps.

Estimates of the MPS's from Specifications that Are Linear in the Coefficients

Estimating equations were obtained for the linear, semi-log, and double-log versions in table 1 by modeling the effect of household demographics as linear explanatory variables and by adding a random error term. The error term is assumed to have a zero mean and a constant variance. Previous studies found no self-selection bias between food stamp recipients and nonrecipients in food expenditures (*5, 12*).

Table 2 defines variables and their sample means. This list comprises variables found by previous studies to be significant in explaining food expenditures. Table 3 gives coefficient estimates for the linear, semi-log, and double-log specifications for both total and at-home food expenditures. The estimated mean ratios across households and their corresponding standard errors are given in table 4.

Table 2—Variable definitions and sample means

Variable		Sample mean
N	Number of food stamp recipients (number of households)	1,210
L	At-home food expenditures in excess of food stamps as a proportion of after-tax income	.34
Food	Monthly expenditure on food at home (dollars)	199.29
Total	Monthly expenditure on all food (dollars)	218.75
Y	Monthly household income after taxes (dollars)	358.17
Y_s	Monthly value of food stamps (dollars)	89.27
Y/Y_s	Income/food stamp ratio	7.43
NUM	Household members (number)	3.15
P1	The proportion of household members under age 3	.06
P2	The proportion of household members between ages 3 and 12	.17
P3	The proportion of household members between ages 13 and 19	.18
P4	The proportion of household members between ages 20 and 39	.11
RACE	= 1 if white; 0 otherwise	.40
REGION	= 1 if household is located in the South; 0 otherwise	.66
U/R	= 1 if household is located in an urban area; 0 otherwise	.53
SLR	= 1 if household had school lunches at reduced prices; 0 otherwise	.41
GM	Number of guest meals served by the household	.60
ELD	= 1 if member of the household is 60 years or older; 0 otherwise	.37
WEL	Assistance programs other than food stamps (number)	.73

For at-home food expenditures, the mean ratio of the MPS's significantly greater than 1 replicates the results from previous studies using the linear-in-the-coefficients specifications. The values reported in table 4 are, however, somewhat larger than those obtained by other studies using post-1979 data except for the estimate reported by Ranney and Kushman. For total food expenditures, the mean ratios are smaller than for at-home expenditures, reflecting income's relatively greater effect on food away from home. Table 5 reports the individual mean MPS's.

Estimates of the MPS's Using the Translog Functional Form

An estimating equation for at-home food expenditure was specified from equation 9, assuming that the cross-section prices were constant:

$$(E - Y_s)/Y = eh_1/eh_2, \tag{11}$$

where

[3]Only for the linear specification will this ratio equal the mean ratio of the MPS's. For other functional forms, in which the MPS's are nonlinear, the ratio of the means will not equal mean ratio.

[4]Prior to January 1979, the Food Stamp Program contained a purchase requirement. Under this program, all households of the same size received the same allotment of food stamps. However, the amount households paid for these stamps varied by household income.

[5]The number of food stamp recipient households who did not spend all their food stamps was about 11 percent of the sample.

Table 3—Estimates of food at home and total food expenditure equations, using specifications that are linear in the coefficients

Variable	At-home food expenditures			Total food expenditures		
	Linear	Semi-log	Double-log	Linear	Semi-log	Double-log
Y	0.08			0.10		
	(0.01)[1]			(.01)		
ln(Y)		35.44	0.40		42.41	0.41
		(4.91)	(.04)		(5.82)	(.04)
Y_s	.48	.50		.41	.44	
	(.05)	(.05)		(.06)	(.06)	
Y_s/Y			.52			.51
			(.06)			(.06)
Constant	26.09	–145.12	2.18	26.63	–176.79	2.16
	(7.96)	(27.38)	(.20)	(9.41)	(32.42)	(.21)
P1	–9.23	–8.13	.12	–26.42	–25.59	.07
	(17.88)	(17.32)	(.09)	(20.53)	(20.50)	(.09)
P2	10.12	6.70	.24	–1.30	–5.23	.23
	(13.71)	(13.68)	(.07)	(16.91)	(16.19)	(.07)
P3	2.21	1.02	.09	9.13	28.24	.23
	(10.45)	(10.22)	(.05)	(4.21)	(12.10)	(.06)
P4	61.55	57.05	.43	70.83	65.49	.47
	(15.10)	(15.05)	(.08)	(17.82)	(17.82)	(.08)
RACE	10.09	9.02	.05	5.93	4.91	.03
	(9.99)	(4.48)	(.02)	(5.30)	(5.31)	(.02)
REGION	–11.70	–10.59	–.02	–10.54	–9.41	–.02
	(4.36)	(4.26)	(.02)	(5.16)	(5.31)	(.02)
U/R	18.35	17.48	.06	19.91	18.74	.06
	(4.27)	(4.26)	(.02)	(5.05)	(5.04)	(.02)
SLR	–5.20	–6.54	–.01	–9.70	–10.57	–.02
	(6.66)	(6.64)	(.03)	(7.89)	(7.86)	(.04)
NUM	25.60	24.37	.10	31.164	30.72	.11
	(1.95)	(1.98)	(.01)	(2.29)	(2.34)	(.01)
GM	10.65	10.51	.05	10.53	10.45	.05
	(1.22)	(1.21)	(.01)	(1.44)	(1.44)	(.01)
ELD	–3.57	–2.80	–.04	–7.46	–10.54	–.06
	(6.06)	(6.03)	(.03)	(7.16)	(7.14)	(.03)
WEL	5.13	4.50	.03	3.71	2.83	.02
	(3.46)	(3.45)	(.02)	(4.08)	(4.08)	(.02)

[1]Standard errors are in parentheses.

Table 4—Mean value of the ratio, $MPS(Y_s)/MPS(Y)$, for at-home and total food expenditures, by alternative functional forms

Functional form	At-home food expenditures	Total food expenditures
Linear-in-the-coefficients specification:		
Linear	6.09	4.14
	(.96)[1]	(.69)
Semi-log[2]	5.06	3.72
	(.68)	(.57)
Double-log	3.82	3.08
	(.46)[3]	(.41)[3]
Translog specification	2.70	2.11
	(.51)[3]	(.45)[3]

[1]Standard errors are in parentheses unless otherwise indicated.
[2]Conditional on mean income.
[3]Standard error of the mean.

Table 5—Mean marginal propensities to spend out of food stamps and income for food at home and total food, by alternate functional form

Functional form	At-home food expenditures		Total food expenditures	
	$MPS(Y_s)$	MPS(Y)	$MPS(Y_s)$	MPS(Y)
Linear-in-the-coefficients specification:				
Linear	0.475	0.078	0.414	0.100
Semi-log[1]	.500	.099	.440	.118
Double-log[2]	.288	.094	.316	.114
Translog specification	.688	.189	.816	.230

[1]Evaluated at the mean food expenditure levels.
[2]Evaluated at the mean income, food stamp, and expenditure levels.

$$eh_1 = c + (SA1-a_{134})\ln(Y_s) - (SA1+SA2)\ln(Y) + 2D'_{ho}Z,$$

$$eh_2 = 1 + SA1\ln(Y_s) - (SA1+SA2+SA3+SA4)\ln(Y) + 4D'_{ho}Z, \text{ and}$$

$$SAi = \sum_j a_{ij} \text{ and } a_{134} = {}_{13} + a_{14}.$$

The intercept term in the denominator of equation 10 has been normalized to 1, and

$$c = a_1+a_2 + (a_{23}+a_{13})\ln(p_a) + (a_{14}+a_{24})\ln(p_x) + (a_{12}+a_{22})\ln(p_f).$$

The lack of price variation in the cross-section precludes estimating the commodity-specific effects of demographic variables identified by D in at-home and total expenditures equations. Instead, each demographic variable is assumed to have a common overall effect on each commodity. These effects are denoted by the k×1 vector D_o. The estimating equation for total food expenditures is:

$$(E + p_aA - Y_s)/Y = et_1/et_2, \tag{12}$$

where

$$et_1 = c' + (SA1-a_{14})\ln(Y_s) - (SA1+SA2+SA3)\ln(Y) + 3D'_{to}Z,$$

$$et_2 = 1 + SA1\ln(Y_s) - (SA1+SA2+SA3+SA4)\ln(Y) + 4D'_{to}Z, \text{ and}$$

$$c' = a_1+a_2+a_3 + (SA2-a_{24})\ln(p_f) + (SA3-a_{34})\ln(p_a) + (SA4-a_{14})\ln(p_x).$$

Both equations 11 and 12 were estimated using nonlinear least squares. These estimates are given in table 6. Demographic variables are defined in table 1.

Table 4 indicates that the mean ratio $MPS(Y_s)/MPS(Y)$ for both at-home and total food expenditures using the translog functional form are greater than 1 but less than the ratios calculated from the specifications that are linear in the coefficients. Based on a two-standard-error interval, the difference is significant for the linear and semi-log but not for the double-log. Consequently, neither the linear nor the semi-log version of the specifications that are linear in the coefficients is supported by the data.

The estimated translog specification gives a mean ratio that is smaller than the ratio of the means. It follows from this condition that households with large $MPS(Y_s)$ also have large MPS(Y). Specifically, the mean ratio for at-home food expenditures is 2.7, while the ratio of the mean MPS's is 3.6.

A positive correlation between the MPS's implies that the potential impact on food expenditures of a cash-payment program would be smaller than if a nonpositive correlation existed. This result follows since households that would have the largest reduction in food expenditures with the loss of food stamps will also be the ones whose increase in food expenditures from the corresponding cash transfer will be the largest.

Since both the linear and semi-log versions imply that the marginal propensities are uncorrelated, the exis-

Table 6—Estimated coefficient of at-home and total food expenditures equations using the translog specification [1]

At-home food expenditures:

$c = \underset{(14.30)}{36.19}$ $\quad SA1 = \underset{(1.25)}{2.95}$ $\quad a_{134} = \underset{(2.16)}{4.06}$

$SA2 = \underset{(2.65)}{3.13}$ $\quad SA3 + SA4 = \underset{(3.58)}{6.59}$

$$D'_{to}Z = \underset{(0.64)}{2.82}\ NUM + \underset{(0.61)}{3.35}\ GM + \underset{(0.59)}{1.91}\ U/R - \underset{(0.44)}{0.54}\ REGION + \underset{(0.47)}{0.72}\ RACE - \underset{(0.99)}{1.59}\ SLR$$
$$- \underset{(2.18)}{3.93}\ P1 + \underset{(1.89)}{0.43}\ P2 + \underset{(1.02)}{0.57}\ P3 + \underset{(2.82)}{9.48}\ P4 - \underset{(0.53)}{0.35}\ EDL + \underset{(0.48)}{1.14}\ WEL$$

Total food expenditures:

$c' = \underset{(22.51)}{34.42}$ $\quad SA1 = \underset{(0.67)}{0.42}$ $\quad a_{14} = \underset{(1.01)}{1.89}$

$SA2 + SA3 = \underset{(2.31)}{4.85}$ $\quad SA4 = \underset{(3.06)}{-7.51}$

$$D'_{to}Z = \underset{(0.52)}{1.53}\ NUM + \underset{(0.40)}{0.85}\ GM + \underset{(0.29)}{0.59}\ U/R - \underset{(0.28)}{0.29}\ REGION + \underset{(0.25)}{0.16}\ RACE - \underset{(0.73)}{1.02}\ SLR$$
$$- \underset{(1.72)}{2.66}\ P1 - \underset{(1.08)}{0.10}\ P2 + \underset{(0.85)}{1.90}\ P3 + \underset{(2.07)}{4.58}\ P4 - \underset{(0.37)}{0.34}\ EDL + \underset{(0.12)}{0.30}\ WEL$$

[1]Standard errors are in parentheses.

tence of a correlation is evidence of the failure of these functional forms to approximate the correct expenditure equation. The MPS's in the double-log version, on the other hand, are negatively correlated. In light of the positive correlation obtained with the more general translog specification, this negative correlation implies an unduly restrictive expenditure equation.

Effect of the Demographic Variables

The marginal impacts of the ith demographic variable on at-home and total expenditures given in equations 11 and 12 are:

$\delta E/\delta Z_i = d_{hoi} \cdot E_d$ and $\delta TE/\delta Z_i = d_{toi} \cdot TE_d$,

where $E_d = (Y/h_2)[2-4(h_1/h_2)]$ and $TE_d = (Y/t_2)[3-4(t_1/t_2)]$, and the d_{oi}'s are the coefficients corresponding to the ith demographic variable. At mean levels, $E_d = 5.34$ and $TE_d = 9.06$.

The demographic variables with the greatest influence on food expenditures are household size and age composition. Both the specifications that are linear in the coefficients and the translog specifications identify family size as a significant determinant of food expenditures. Both specifications exhibit large economies of household size. At mean levels, an increase of one family member is calculated to increase food expenditures by approximately \$25 for the specifications that are linear in the coefficients and by approximately \$15 for the translog specification. These values compare with an average food expenditure per household member of \$64.

Both specifications also identify: (1) that an increase in the proportion of family members less than 3 years old reduces food expenditures (however, the effect is not precisely estimated), (2) that an increase in the proportion of family members between 20 and 39 years old increases food expenditures, and (3) that a larger proportion of members between 13 and 19 years of age increases total food expenditures but not at-home food expenditures.

The major difference between the translog specification and the specification that is linear in the coefficients in identifying demographic determinants of food expenditures occurred with the variable measuring the enrollment in other welfare programs. The translog specification identified this variable as significant in determining food expenditures. This result suggests the existence of cross-program effects. Other variables generally found to be significant by all specifications in determining food expenditures were the number of guest meals and living in an urban area. The linear version for both types of expenditures and the semilog for at-home food expenditures also identified region as a significant factor.

Implication of the Estimated MPS's for a Cash-Only Food Stamp Program

A ratio of the MPS's greater than 1 has been used to argue that cash payments instead of food stamps would cause a decline in food expenditures. However, the ratio of the MPS's can be used in this manner only if the functional form is linear. For other functional forms with nonlinear marginal propensities, no single point can measure the impact of a cash-only program.

Replacing food stamps with cash would have two effects on food expenditures. First, food expenditures would decline because of the loss of food stamps. In general, the decline in expenditures can be measured by integrating $MPS(Y_s)$ over $[Y_s, 0]$, holding income constant. This decline in expenditures can be calculated from the food expenditure function, E, as $E(0,Y) - E(Y_s,Y)$. The second effect would be an increase in food expenditures resulting from the income transfer equal to the value of the food stamps. This increase in food expenditures equals $E(0,Y+Y_s) - E(0,Y)$. The expenditure levels will depend significantly upon the nonlinearity of the food expenditure function. In general, the MPS(Y) is a nonlinear function of food stamp benefits, and income and food stamp benefits are substitutes in food expenditures. Therefore, replacing food stamps with cash causes the MPS(Y) schedule to shift to the right so that the marginal propensity to spend on food out of income is greater at every level of income.

The impact on food expenditures of a cash-only program was initially measured by calculating the magnitude of the decline in food expenditures from the loss of food stamp benefits *relative* to the gain resulting from the income transfer.[6] The proportion calculated in this manner was defined as the "expenditure ratio" and is comparable to the ratio of the MPS's in table 4. Values of the expenditure ratio for each specification are given in table 7 and illustrate wide variation. At one extreme, the reduction in food expenditures from the loss of food stamp benefits is predicted to be five times larger than the increase resulting from the cash transfer. At the other extreme, the food expenditure equation based on the translog indirect utility function predicts that the loss in total food expenditures would be 33 percent greater than the gain from the income transfer.

An alternative, or second way of measuring the effect on food expenditures of a cash-only food stamp program was obtained by calculating the dollar reduction in food expenditures for each dollar of food stamp ben-

[6]The results in tables 7 and 8 do not reflect the full effect on food expenditures of a program in which all food stamps are eliminated. Instead, the calculations assigned a \$10 lower limit to food stamp benefits. This level of benefits is the minimum number guaranteed to all recipient households. The estimates reported in tables 7 and 8 are, therefore, consistent with the range of food stamp benefits observed in the estimating sample.

Table 7—Expenditure ratios measuring the effect of a cash-only food stamp program for at-home and total food expenditures, by alternative functional form [1,2,3]

Functional form	At-home food expenditures	Total food expenditures
Linear-in-the-coefficients specification:		
Linear	6.09	4.14
	(.96)	(.69)
Semi-log	5.06	3.72
	(.08)	(.06)
Double-log	1.46	1.38
	(.05)	(.04)
Translog specification	1.40	1.33
	(.08)	(.07)

[1]Numbers in parentheses are standard errors of the mean, unless otherwise indicated.
[2]The expenditure ratio is the loss of food expenditures resulting from the loss of food stamp benefits *relative* to the gain in food expenditures resulting from the corresponding income transfer.
[3]Instead of assuming a cash-only food stamp program with no stamps, a minimum level of food stamp benefits of $10 was used. This level of benefits is guaranteed to all recipients. The result is, therefore, within sample estimates consistent with the estimating sample of food stamp recipients.

efits converted to income. This measure is given in table 8 for each specification and for both at-home and total food expenditures. The results of the various specifications exhibit large absolute divergences, again illustrating the importance of the choice of functional form. For the double-log and the translog specifications, the average reduction in food expenditures for each dollar of food stamp benefits converted to income is approximately 10 cents. For the linear and semi-log specifications, the average decline is approximately 38 cents per dollar of food stamp benefits converted.

Conclusion

The marginal propensity to spend on food estimated using specifications that are linear in the coefficients overstates the impact of food stamps relative to income for generating both at-home and total food expenditures. Significant opposition to a cash-only program has been based on a belief that food consumption would fall significantly if cash were provided in lieu of stamps. This article concludes that the estimated effect of a cash-only food stamp program on net food expenditures depends upon the functional form used to estimate the MPS's. However, this conclusion holds only for households that are enrolled in the program and that spend all their stamps.

When the MPS's are nonlinear, as the results from the translog specification indicate, the ratio of the mean MPS's (or the mean ratio) cannot measure the effect on food expenditures of a cash-only program. Instead, the change in expenditures evaluated at the appropriate levels of food stamp benefits and income must be calculated.

Table 8—Average dollar reduction in at-home and total food expenditures per dollar of food stamp benefits converted to income, by functional form [1]

Functional form	At-home food expenditures	Total food expenditures
	Dollars [2]	
Linear-in-the-coefficients specification:		
Linear	0.397	0.314
	(.003)	(.002)
Semi-log	.448	.363
	(.003)	(.003)
Double-log	.103	.094
	(.004)	(.004)
Translog specification	.114	.108
	(.009)	(.007)

1Instead of assuming a cash-only program, a minimum level of food stamp benefits of $10 was used. This level of benefits is guaranteed to all recipients. The result is, therefore, within sample estimates, consistent with the estimating sample of food stamp recipients.
[1]Standard error of the mean in parentheses.

The effect on food expenditures calculated using the two most flexible specifications (the translog and double-log) was smaller than predicted by the ratio of their MPS's. For both of these specifications, the average reduction in food expenditures for each dollar of food stamp benefits converted to income is approximately 10 cents. This suggests that the loss of food expenditures associated with a cash-only program may be less than previously imagined.

Even if food stamps and income had identical effects on food expenditures, any conversion of the Food Stamp Program to a cash-only program would face other obstacles. For example, taxpayers have a strong preference for a program that is tied explicitly to food. In addition, as a food program, the Food Stamp Program can maintain a unique identity that distinguishes it from other cash welfare programs run by different agencies. An important aspect of a cash-only program that has not been addressed in this paper is the magnitude of the increased enrollment of eligible nonparticipants that such a program likely would create.

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The Effects of Domestic Agricultural Policy Reform on Environmental Quality

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Abstract. *A general equilibrium model is developed to study the environmental implications of agricultural policies. Model results show that declines in the acreage reduction program (ARP) would reduce agricultural fertilizer use, but the return of ARP land to production would lead to an overall increase in sedimentation and offsite environmental damage. In contrast, if land and fertilizers are highly substitutable, declines in deficiency payments and other commodity price support programs would reduce offsite environmental damages by reducing fertilizer use. Agricultural policy reform would be consistent with conservation policy because it would encourage a reduction in the use of fertilizer-intensive production practices.*

Keywords. *Policy reform, trade liberalization, general equilibrium, conservation reserve program, environmental quality.*

Two major agricultural issues have triggered considerable public policy discussion at both the national and international level: agricultural policy reform and the environmental side effects of agricultural production. The desire to reduce market distortions, high farm program costs, and expensive surplus commodity stocks has fueled policy reform debate.

The second issue, concern over agriculture's impact on the environment, has grown from agriculture's sometimes harmful side effects. The environmental lobby became a significant player for the first time in the design of the Food Security Act (FSA) of 1985, which introduced significant new programs to protect natural resources. Environmental considerations also entered into the 1990 Food, Agriculture, Conservation, and Trade Act.

This article advances consideration of these two issues by showing how a simple specific-factor model can be empirically computed to investigate the relationships between agricultural policies, resource use, and environmental quality. We study policy reform in a general equilibrium framework, focusing on resource use and environmental implications. A unique feature of our analysis is the explicit specification of an environmental damage function, derived from the work by Ribaudo (*23*).[1]

The Model

The model is formulated as a general equilibrium system to evaluate the ultimate tradeoffs between environmental quality, production, and income. In a general equilibrium system, agricultural production is affected by cross-sectoral flows of factors of production and intermediate inputs and by the income effects of policy changes on the demand and supply of other goods. This model, although a general equilibrium system, is only modestly more complicated in its solution than a partial equilibrium system. There are three production sectors in the model: agriculture, manufacturing, and nontraded goods. Environmental degradation is modeled as a joint product in the output of agriculture. However, since there is assumed to be no market for this output, the market equilibrium is found by dropping the equation for environmental damages.

The following production functions describe the structure of the economy:

$$X_1 = f_1(L_1, K_1, T, S, X_{31}) \quad \text{(agriculture)}$$

$$X_2 = f_2(T, S, X_{31}) \quad \text{(environmental damages)}$$

$$X_3 = f_3(L_3, K_3) \quad \text{(manufactures)}$$

$$X_4 = f_4(L_4, K_4) \quad \text{(nontraded goods)}$$

X_j denotes the output of section j. L_j denotes the labor input into production in sector j. X_{31} represents intermediate chemical fertilizers from the manufacturing sector to the agricultural sector.[2] T and S are agricultural-specific factors that represent nonerodible land (NEL) and highly erodible land (HEL), respectively (*8*). We assume that the two types of land are highly, but not perfectly, substitutable. Land is identified in this manner to facilitate modeling the conservation reserve program (CRP). This method of modeling agricultural land is conceptually similar to that of Hertel and Tsigas (*15*) and Robidoux and Smart (*24*).

K_j denotes the input of capital into the production in sector j. We assume that labor is perfectly mobile among sectors, while capital is sector specific, because we are interested in exploring policy scenarios that are consistent with the intermediate-run timeframe, and

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

[2]Pesticides are not included in our equations because their contribution to total environmental damages from agriculture is not well known.

reaffirming that farm structures and some types of capital are relatively immobile in the short run to medium run (*13*). The association of the intermediate run with capital specificity is also consistent with the trade literature on which our economic model is grounded (*17*).

To present this model as a general equilibrium system of equations, we introduce some additional variables: w, r_{Ki}, r_T, and r_S, respectively, are the wage rate, the rental rate on capital in sector i, the rental rate on NEL, and the rental rate on HEL; p_j is the price of good j, and P_1^* is the world price of the agricultural goods; a_{ij} is the conditional input coefficient representing the input of factor or intermediate good i into the production of a unit of good j; D_j is the domestic consumption of good j; and I represents national income.

Given this notation and the assumptions of constant returns to scale in production and perfect competition in all markets, we can formulate the following general equilibrium system in the tradition of the Jones model of international trade (*18*):

$$L = a_{L1}X_1 + a_{L3}X_3 + a_{L4}X_4 \tag{1}$$

$$K_1 = a_{K1}X_1 \tag{2}$$

$$K_3 = a_{K3}X_3 \tag{3}$$

$$K_4 = a_{K4}X_4 \tag{4}$$

$$T = a_{T1}X_1 \tag{5}$$

$$S = a_{S1}X_1 \tag{6}$$

$$P_1 = wa_{L1} + r_{K1}a_{K1} + r_Ta_{T1} + r_Sa_{S1} + P_3a_{31} \tag{7}$$

$$P_3 = wa_{L3} + r_{K3}a_{K3} \tag{8}$$

$$p_4 = wa_{L4} + r_{K4}a_{K4} \tag{9}$$

$$a_{L1} = a_{L1}(w, r_{K1}, r_T, r_S, P_3) \tag{10}$$

$$a_{K1} = a_{K1}(w, r_{K1}, r_T, r_S, P_3) \tag{11}$$

$$a_{T1} = a_{T1}(w, r_{K1}, r_T, r_S, P_3) \tag{12}$$

$$a_{S1} = a_{S1}(w, r_{K1}, r_T, r_S, P_3) \tag{13}$$

$$a_{31} = a_{31}(2, r_{K1}, r_T, r_S, P_3) \tag{14}$$

$$a_{L3} = a_{L3}(w, r_{K3}) \tag{15}$$

$$a_{K3} = a_{K3}(w, r_{K3}) \tag{16}$$

$$a_{L4} = a_{L4}(w, r_{K4}) \tag{17}$$

$$a_{K4} = a_{K4}(w, r_{K4}) \tag{18}$$

$$D_1 = D_1(I, P_1, P_3, P_4) \tag{19}$$

$$X_4 = D_4(I, P_1, P_3, P_4) \tag{20}$$

$$I = P_1X_1 + P_3X_3 + P_4X_4 - P_3a_{31}X_1 - (PSE)P_1^*(X_1 - D_1) \tag{21}$$

$$P_1 = P_1^* \tag{22}$$

Equations 1-6 are full-employment conditions, and equations 7-9 are the zero-profit conditions. Equations 10-18 are the conditional input-output coefficient functions. Because we want to focus primarily on the agricultural sector, we include equation 19, which gives the demand for agricultural goods. Equation 20 is the equilibrium condition for the service, or nontraded goods sector. Equation 21 defines the dollar price of national income, and equation 22 defines the domestic-currency price of the agricultural good. There are 22 equations and 22 endogenous variables (X_1, X_3, X_4, D_1, w, r_T, r_S, r_{K1}, r_{K3}, r_{K4}, a_{L1}, a_{T1}, a_{S1}, a_{31}, a_{K1}, a_{L3}, a_{K3}, a_{L4}, a_{K4}, P_1, P_4, and I). The model is completely specified.

From this general equilibrium model, we derive the following linearized system of equations of change:

$$\lambda_{L1}\hat{X}_1 + \lambda_{L3}\hat{X}_3 + \lambda_{L4}\hat{X}_4 = -\lambda_{L1}\hat{a}_{L1} - \lambda_{L3}\hat{a}_{L3} - \lambda_{L4}\hat{a}_{L4} \tag{1b}$$

$$\hat{X}_1 = -\hat{a}_{K1} \tag{2b}$$

$$\hat{X}_1 = -\hat{a}_{K3} \tag{3b}$$

$$\hat{X}_1 = -\hat{a}_{K4} \tag{4b}$$

$$\hat{X}_1 = \hat{T} - \hat{a}_{T1} \tag{5b}$$

$$\hat{X}_1 = \hat{S} - \hat{a}_{S1} \tag{6b}$$

$$\Theta_{L1}\hat{w} + \Theta_{K1}\hat{r}_{K1} + \Theta_{T1}\hat{r}_T + \Theta_{S1}\hat{r}_S = \hat{P}_1 \tag{7b}$$

$$\Theta_{L3}\hat{w} + \Theta_{K3}\hat{r}_{K3} = 0 \tag{8b}$$

$$\Theta_{L4}\hat{w} + \Theta_{K4}\hat{r}_{K4} = \hat{P}_4 \tag{9b}$$

$$\hat{a}_{L1} = \sigma^1_{LL}\Theta_{L1}\hat{w} + \sigma^1_{LK}\Theta_{K1}\hat{r}_{K1} + \sigma^1_{LT}\Theta_{T1}\hat{r}_T + \sigma^1_{LS}\Theta_{S1}\hat{r}_S \tag{10b}$$

$$\hat{a}_{K1} = \sigma^1_{KL}\Theta_{L1}\hat{w} + \sigma^1_{KK}\Theta_{K1}\hat{r}_{K1} + \sigma^1_{KT}\Theta_{T1}\hat{r}_T + \sigma^1_{KS}\Theta_{S1}\hat{r}_S \tag{11b}$$

$$\hat{a}_{T1} = \sigma^1_{TL}\Theta_{L1}\hat{w} + \sigma^1_{TK}\Theta_{K1}\hat{r}_{K1} + \sigma^1_{TT}\Theta_{T1}\hat{r}_T + \sigma^1_{TS}\Theta_{S1}\hat{r}_S \tag{12b}$$

$$\hat{a}_{S1} = \sigma^1_{SL}\Theta_{L1}\hat{w} + \sigma^1_{SK}\Theta_{K1}\hat{r}_{K1} + \sigma^1_{ST}\Theta_{T1}\hat{r}_T + \sigma^1_{SS}\Theta_{S1}\hat{r}_S \tag{13b}$$

$$\hat{a}_{31} = \sigma^1_{3L}\Theta_{L1}\hat{w} + \sigma^1_{3K}\Theta_{K1}\hat{r}_{K1} + \sigma^1_{3T}\Theta_{T1}\hat{r}_T + \sigma^1_{3S}\Theta_{S1}\hat{r}_S \tag{14b}$$

$$\hat{a}_{L3} = \sigma^3_{LL}\Theta_{L3}\hat{w} + \sigma^3_{LK}\Theta_{K3}\hat{r}_{K3} \tag{15b}$$

$$\hat{a}_{K3} = \sigma^3_{KL}\Theta_{L3}\hat{w} + \sigma^3_{KK}\Theta_{K3}\hat{r}_{K3} \tag{16b}$$

$$\hat{a}_{L4} = \sigma^4_{LL}\Theta_{L4}\hat{w} + \sigma^4_{LK}\Theta_{K4}\hat{r}_{K4} \tag{17b}$$

$$\hat{a}_{K4} = \sigma^4_{KL}\Theta_{L4}\hat{w} + \sigma^4_{KK}\Theta_{K4}\hat{r}_{K4} \tag{18b}$$

$$\hat{D}_1 = e_{11}\hat{P}_1 + e_{14}\hat{P}_4 + \eta_1(\hat{I} - v_1\hat{P}_1 - v_4\hat{P}_4) \tag{19b}$$

$$\hat{X}_4 = e_{41}\hat{P}_1 + e_{44}\hat{P}_4 + \eta_4(\hat{I} - v_1\hat{P}_1 - v_4\hat{P}_4) \tag{20b}$$

$$\hat{P}_1 = E_1(\hat{X}_1 - \hat{D}_1)\hat{P}_1^* \tag{22b}$$

The circumflex signifies a proportional rate of change ($\hat{X}_1 = dx_1/x_1$). λ_{ij} denotes the proportions of factor i used in sector j, Θ_{ij} denotes the share of factor i in the output of sector j, σ^j_{ik} is the Allen partial elasticity of substitution between inputs i and k in sector j, e_{ij} is the price j, compensated elasticity of demand for good i, η_j is the income elasticity sector-j demand, v_j is the share of good j in consumption, and E_1 in equation 22b is the price elasticity of export demand for agricultural commodities. Inclusion of equation 22b shows that the United States, with respect to world agriculture, has some market power and, therefore, affects world agricultural prices. The appendix contains the derivation of the change in the real income of the economy ($\hat{I} - v_1\hat{p}_1 - v_4\hat{p}_4$) and the sources of the share and elasticity parameters.

Policy Reform and the CRP

To this model, two policy shocks are introduced: increased Conservation Reserve Program (CRP) participation and commodity policy reform. The CRP is a voluntary, long-term program initially aimed at withdrawing 40-45 million acres of highly erodible land from production. It is the most ambitious agricultural conservation program to date. Enrollment in the program has been relatively constant since February 1989 at about 31 million acres, or 7.6 percent of total 1989 cropland (*30*). The primary objectives of this program include controlling offsite damages of erosion, protecting longrun agricultural productivity by reducing soil erosion, and promoting wildlife habitat. The CRP enters our model as an exogenous change in the endowment of land resources. Commodity policy reform is defended by proponents primarily for the desirability of removing production distortions and reducing the burden of agricultural commodity programs on the Federal budget.

Agricultural programs provide support for producers through a broad range of policies. Most important are direct payments, market price support, input subsidies, marketing subsidies, State programs, and taxation policies. We consider here only the effect of reducing the level of support programs that act as output wedges, that is, the programs that distort the level of production primarily by inducing farmers to produce a larger quantity of output than would otherwise be the case. The most important programs in this category include price supports/quotas and deficiency payments. We do not consider the economic effects of reducing input subsidies (commodity loans, Farmers Home Administration programs, subsidies for land improvements), which create primary factor wedges.

The producer subsidy equivalent (PSE) has been used as a measure of output and primary factor wedges (*25*, *26*). It is defined as the level of producer subsidy that would be necessary to compensate producers for the removal of government programs affecting commodities.[3] The average PSE during 1982-86 for 12 commodities (wheat, corn, rice, sorghum, barley, oats, soybeans, dairy, sugar, beef, veal, and poultry), not including input subsidies, was 21.4 percent of total producer value, or \$23.2 billion (*32*). Since this transfer accounts for the vast majority of total U.S. agricultural policy transfers, we use it to derive a PSE for all U.S. agriculture. We find the average PSE for all agricultural commodities during 1982-86 to be 17.2 percent by dividing \$23.2 billion by the average value of U.S. agricultural output (\$135 billion) over the same period (*33*).

The PSE enters our model through equation 22 as an *ad valorem* price subsidy to agriculture. Equation 22 now becomes:

$$P_1 = P_1^*(1 + PSE).$$

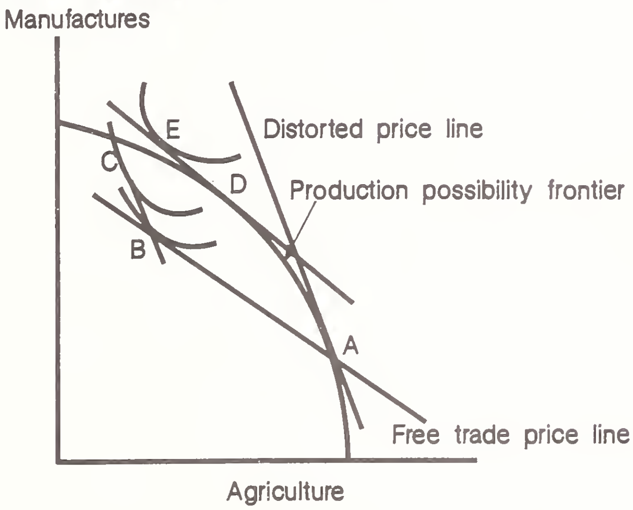
Equation 22b becomes:

$$\hat{P}_1 = E_1(\hat{X}_1 - \hat{D}_1)\hat{P}_1^* + dPSE/(1 + PSE).$$

Figure 1 shows how the price wedge introduced by commodity price supports and export subsidies affects our model. With subsidies, production takes place at point A, the tangency of the domestic (distorted) price line with the production possibilities frontier. Consumers, however, face world prices and would consume at point B, but the subsidy distorts consumption and production. Thus, point C is the distorted consumption point. With removal of the agricultural price wedge, production and consumption move to points D and E. Exports of agricultural goods are reduced, while exports of manufactures increase. The economy is better off when it operates on a higher community indifference curve (CIC). In our model, the income equation (equation 21) reflects the fact that it is not

[3]For a more complete definition of PSE's, see (*32*).

Figure 1
Removal of commodity price supports and export subsidies



possible to increase economywide income by subsidizing exports.

Not captured in the PSE, but closely linked with it, is the Acreage Reduction Program (ARP), the Federal Government's largest annual cropland retirement program. It is designed to reduce total planted acres when national supplies of agricultural commodities are projected to be high. The 1982-86 average ARP participation level was 38.6 million acres (*30*). ARP participation is required of agricultural producers if they are to maintain eligibility for Federal agricultural support program benefits. Like the CRP, the ARP enters our model as an exogenous change in the endowment of land resources.

Figure 2 shows that an increase in land available for agricultural production shifts the production possibility frontier of agriculture and manufactures outward (from PPF_1 to PPF_2) along the agricultural axis. The initial production point, where the price line is tangent to the initial frontier, is point A. Consumption occurs at point B, the tangency of the price line with the initial community indifference curve (CIC_1). The initial production and consumption equilibrium illustrates that, in this model, agriculture is considered the export good, while manufactures are considered the import good. The production and consumption points, with an increase in agricultural land, are given by C and D, respectively. The economy is better off—it operates on a higher community indifference curve (CIC_2)—and agricultural exports (production less consumption) rise.

Environmental Damages

To assess the direct and indirect effects of the CRP and policy reform on environmental quality, we specified an agricultural environmental damage equation. The proportional change in environmental damages (ED) is given by the sum of proportional changes in the use of HEL, NEL, and fertilizers, weighted by each factor's contribution to total agricultural environmental damage:

$$\hat{ED} = D_{HEL}\hat{S} + D_{NEL}\hat{T} + D_{CHEM}\hat{X}_{31},$$

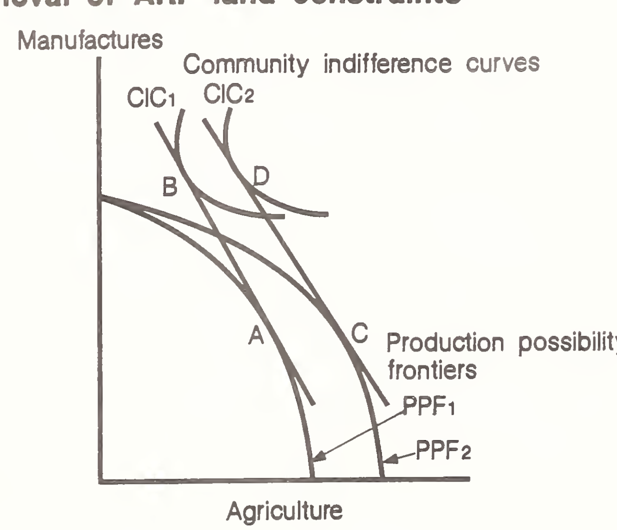
where D_{HEL}, D_{NEL}, and D_{FERT} are the contribution of HEL, NEL, and fertilizer to total agricultural environmental damages.

Because our focus is on the environmental effects of farm policy changes, the environmental damage function reflects only damages from farming. It does not consider environmental damage from the manufacturing and service sectors. We think it is reasonable to consider only agri-environmental damages related to agricultural policy changes because farm agriculture accounts for only about 2 percent of the total economy. Consequently, agricultural policy changes have little effect on production and pollution emissions in the manufacturing and service sectors.

Ribaudo (*23*) provides estimates of offsite environmental damages from agricultural emissions of nitrogen, phosphorus, and suspended sediment, which harm freshwater and marine recreation, water storage, navigation, flooding, roadside and irrigation ditches, freshwater and marine commercial fishing, municipal water treatment, municipal and industrial use, and steam power cooling. We used Ribaudo's damage estimate to determine that the contribution of agricultural chemicals to total agricultural environmental damage is 23 percent.

The share of highly erodible land and nonerodible land in the remaining 77 percent of total agricultural environmental damages is estimated from the fact that

Figure 2
Removal of ARP land constraints



highly erodible land accounts for 63 percent of the cropland sheet, rill, and wind erosion (*31*). Highly erodible land's contribution to damage is 63 percent of 77, or 48.5 percent. Nonerodible land's contribution is, consequently, 28.5 percent.

Although the damage function is crude, it contains the best information available on specific environmental damage due to sediment delivered from cropland. We believe that it is sufficiently robust to provide some preliminary and meaningful indications of the relative magnitudes and directions of change of surface water environmental damages from the introduction of policy shocks, in this case of policy reform and increased CRP participation. Additional work in measuring the environmental consequences of agricultural production would be useful.

Policy Experiments

Two CRP scenarios are considered: no change from the present enrollment of about 31 million acres and an increase in enrollment to 45 million acres. Under the first scenario, two levels of simultaneous ARP and PSE commodity policy reform (20-percent and 40-percent reductions in the base level), and the separate impact of a 40-percent reduction in the ARP and the PSE are considered. The 1982-86 average PSE and ARP in the United States (17.2 percent and 38.6 million acres, respectively) are used as the benchmarks for the PSE and ARP levels. The second scenario assesses the effect of an increase in the CRP without any other changes in policy.

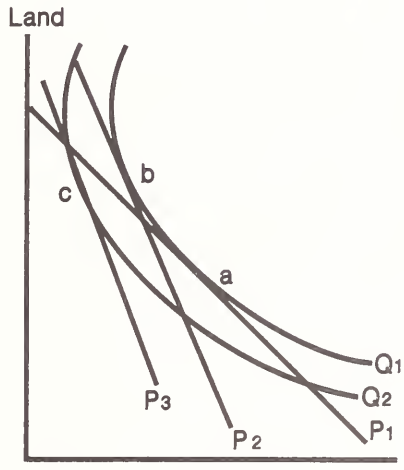
Reductions in the ARP reduced agricultural fertilizer use, but the return of ARP land to production leads to an increase of offsite environmental damages (table 1). This result is consistent with the empirical efforts of Shoemaker and Offutt, who find a historical positive bias associated with chemicals and acreage control programs (*29*). In contrast, declines in the PSE reduce offsite agricultural environmental damages by reducing fertilizer use. The positive environmental effect of a reduction in the PSE dominates the negative environmental effect of an equivalent percentage reduction in the ARP. In fact, the positive environmental effect of simultaneous PSE and ARP reduction is so strong that even modest policy reform (20 percent) generates environmental benefits nearly as great as an increase in the CRP to 45 million acres. This suggests that policy reform is consistent with conservation policy because it encourages a reduction in the use of fertilizer-intensive production practices.

Reduced fertilizer use is a result of two effects: the output effect and the substitution effect (fig. 3). Economic optima are provided when the ratio of resource prices (P_1) equals the marginal rate of substitution of fertilizers for land (point *a*). The substitution effect is reflected in the movement from *a* to *b* caused by changes in input prices (from P_1 to P_2). In our analysis, both ARP and PSE reform increase the price of fertilizer relative to land and, consequently, reduce the fertilizer/land ratio in production. ARP reform places more land in production, reducing the marginal physical product and returns to land. With land cheaper and fertilizer prices unchanged, farmers

Table 1—Percentage change in endogenous variables

Variables	Scenario one CRP = 31 million acres: Simultaneous reduction in both ARP and PSE of: 20 percent	Scenario one: Simultaneous reduction in both ARP and PSE of: 40 percent	Scenario one: Reduction in ARP of 40 percent	Scenario one: Reduction in PSE of 40 percent	Scenario two CRP = 45 million acres: No policy reform
Environmental damages ($\hat{ED}$)	–4.30	–8.50	2.60	–11.20	–5.40
Output:					
Agriculture ($\hat{X}_1$)	–3.50	–6.90	1.90	–8.80	–1.70
Manufactures ($\hat{X}_3$)	.06	.10	–.01	.10	.10
Services ($\hat{X}_4$)	.04	.09	–.01	.09	.01
Fertilizer inputs:					
Agriculture ($\hat{X}_{31}$)	–25.10	–50.10	–1.70	–48.50	1.50
Labor inputs:					
Agriculture ($\hat{L}_1$)	–10.40	–20.70	1.90	–22.60	–1.67
Manufactures ($\hat{L}_3$)	.09	.15	–.02	.15	.01
Services ($\hat{L}_4$)	.07	.13	–.01	.15	.01
Wage rate ($\hat{w}$)	–.05	–.09	.01	–.10	–.01
Returns to capital:					
Agriculture ($\hat{r}_{K1}$)	–21.60	–43.30	.80	–44.10	–.70
Manufactures ($\hat{r}_{K3}$)	.10	.30	–.02	.30	.02
Services ($\hat{r}_{K4}$)	.09	.20	–.02	.20	.01
Returns to land:					
Highly erodible land ($\hat{r}_S$)	–20.50	–41.00	–2.70	–38.00	4.20
Nonerodible land ($\hat{r}_T$)	–20.50	–41.00	–2.70	–38.00	1.70

Figure 3
Substitution and output effects of policy reform



shift away from fertilizers, which are a land substitute. PSE reductions also reduce the return to land and, consequently, the fertilizer/land ratio in production.

Agricultural policy not only creates static distortions in input markets, represented by the movement from *a* to *b*, but it also distorts the nature of longrun research and development. Ruttan (*27*), Reichelderfer (*21*), and the National Research Council (*19*) observed that scientific and technical innovation in both the public and private sectors have been overly biased toward the development of land substitutes—plant protection chemicals and crop varieties and management systems that reflect the overvaluation of land and undervaluation of the social costs of the disposal of residuals from agricultural production practices.

The output effect is represented by the inward shift of the production isoquant (from Q_1 to Q_2) and the movement from equilibrium point *b* to *c*. At point *c*, the new isoquant (Q_2) is tangent to the adjusted factor price ratio (P_3). In our analysis, the production isoquant shifts inward as a result of the simultaneous reduction of the PSE and ARP (although reducing the ARP increases agricultural output, the output-reducing effect of an equivalent percentage reduction in the PSE dominates).

The effect of policy reform in reducing the return to land illustrates the fact that government commodity support payments are largely capitalized in asset values (land), negating the shortrun policy-induced increases in agricultural income (*6*, *12*, *25*). Land values represent the present value of the expected net returns to agricultural production; reducing or eliminating support programs reduces expected future returns.

Increasing the CRP to 45 million acres, in contrast, takes highly erodible land out of production and reduces agricultural output and economywide income. With constant prices and an increase in the marginal physical product of highly erodible land, the return to land rises. For the zero profit condition to hold, the return to agricultural capital and labor must fall. Labor migrates out of agriculture, and fertilizer inputs are substituted for land inputs as the employed endowment of land is reduced. With the CRP at 45 million acres, and assuming no policy reform, the return to highly erodible land rises by 4.2 percent. Under the paid diversion feature of the CRP, farmers must receive this rental increase on highly erodible land to induce them to participate in the program.

The reduction in fertilizer use with policy reform rests strongly on the elasticity of substitution between land and fertilizers. The more substitutable they are, the greater the reduction in fertilizer use. As shown in the appendix, we set the Allen elasticity of substitution between fertilizers and land at 2.9. It is not clear whether this should be considered an overly optimistic estimate of land and fertilizer substitutability, or a low estimate. Most estimates of substitution elasticities do not specify land and fertilizer (*3*, *4*, *20*). However, in a comparative study of agricultural development, Hayami and Ruttan (*10*) suggest that land and fertilizer are strongly substitutable. Hertel and others, however, have estimated the Allen elasticity between land and fertilizer to be 0.68 for the United States (*14*). To test the sensitivity of environmental damages to this critical elasticity parameter, we reduced the elasticity of substitution between fertilizers and land to 1 and imposed a 40-percent reduction on the PSE and ARP. Again, policy reform produced environmental benefits, but in this case only marginally ($\dot{E}D = -0.4$).

Conclusions

Our stylized model illustrates some important relationships among agricultural policies, resource use, and environmental quality. Given the structure of the present model and its parameters, policy reform (of the ARP and other agricultural support programs) tends to reduce the negative environmental externalities from cropland production. Although policy reform ameliorates undesirable environmental effects, it cannot be a complete solution to an environmental problem associated with agricultural production, because agricultural programs are not the root source of the problem. The root source derives from the lack of markets for the use of the environment. Pollution control programs independent of government support programs are required to attain an "optimal" level of environmental quality.

The linkages between agriculture and the environment are complex. Our analysis has uncovered some important relationships, and our policy experiments have led

to some interesting observations, but we also realize the strong need for further research. For example, we noted the importance of some critical parameters, such as the elasticity of substitution between fertilizer and land.

Other efforts might further disaggregate the agricultural sector to better capture the complexities of agricultural commodity programs and changes in the composition of agricultural production—changes that have important environmental implications since some crops are more "pollution intensive" than others. The principal difficulty in new research involves the construction of an environmental social accounting matrix that describes environmental effects associated with different agricultural activities. The matrix would form the framework for estimating total environmental damages stemming from agricultural production.

Because it is not possible to measure directly emissions from agricultural nonpoint sources of pollution, estimating total agricultural environmental damages through the construction of damage equations is critical for policy modelers seeking to compare the efficacy of measures to reduce environmental damage from agricultural production. We have assumed in this article a linear and separable damage function where the damage from each input is independent of the level of the other inputs. Future research might relax these assumptions.

Appendix

Income Effects

The production possibilities of the economy are given by:

$$p_1 dX_1 + p_3 dX_3 + p_4 dX_4 - p_3 dX_{31} = r_T dT + r_S dS. \quad \text{(A-1)}$$

The income of the economy is given by:

$$I = P_1X_1 + P_3X_3 + P_4X_4 - P_3 a_{31} X_1 - (PSE)P_1^*(X_1 - D_1). \quad \text{(A-2)}$$

By totally differentiating equation A-2 and imposing equation A-1, we obtain:

$$dI = X_1 dP_1 + X_4 dP_4 - (PSE)P_1^* dX_1 + (PSE)P_1^* dD_1 - P_1^*(X_1 - D_1)dPSE + r_T dT + r_S dS - (PSE)(X_1 - D_1)dP_1^*. \quad \text{(A-3)}$$

The formula for the real income of the economy is given by:

$$(\hat{I} - v_1\hat{p}_1 - v_4\hat{p}_4) \equiv \frac{dI}{I} - \frac{p_1D_1}{I}\frac{dp_1}{p_1} - \frac{p_4D_4}{I}\frac{dp_4}{p_4} \quad \text{(A-4)}$$

We substitute equation A-3 into A-4 to obtain:

$$(\hat{I} - v_1\hat{p}_1 - v_4\hat{p}_4) = \Phi_T\hat{T} + \Phi_S\hat{S} - \frac{(PSE)}{(1 + PSE)}(\Phi_1\hat{X}_1 - v_1\hat{D}_1) + \frac{(\Phi_1 - v_1)}{(1 + PSE)}P_1^*, \quad \text{(A-5)}$$

where $\Phi_T = r_T T/I$, $\Phi_S = r_S S/I$, and $\Phi_1 = P_1X_1/I$.

The first two terms on the right-hand side of equation A-5 show the proportional increase in real income arising from changes in the stock of nonerodible and highly erodible land, respectively. The third term shows the proportional decline in real income that comes from an increase in export subsidy and deficiency payments.

Data Sources

As with any economic model, the structure and parameters of the model drive the results. For this reason, we carefully reviewed the literature to ensure that parameters were assigned that realistically reflected the economy and the structure of the model. The employment shares, λ_{ij}, expenditure shares, v_j, value-added shares, Φ_T, Φ_S, and Φ_1, and product shares, Θ_{ij}, in appendix table 1 are calculated from a social accounting matrix derived from (*9*). We calculated the land-value-added shares by assuming that 60 percent of capital value added in agriculture is the land-value-added component (*22*). Land value added is then divided into nonerodible and highly erodible land based on the proportion of total cropland which is nonerodible and highly erodible, 29.4 and 70.6 percent, respectively (*30*).

Appendix table 2 furnishes elasticity values. The cross-price, Allen elasticities of substitution for agriculture, σ^1_{ik}, i = k, are taken from (*2*). Own-price elasticities are calculated using the adding-up constraint ($\sum_k \sigma^j_{ik}\,\Theta_{kj} = 0$) (*28*). Binswanger estimates a translog cost function for U.S. agriculture using time-series data (*2*). For our purposes, Binswanger's estimates are particularly appropriate because, unlike most studies (*3*, *4*, *20*), the identified factors of production include both land and fertilizers. While Hertel and others (*14*) also include land and fertilizer, their aggregation scheme is quite different from the one used here. In addition, it is assumed that NEL and HEL substitute identically with other factors of production, that is, $\sigma^1_{LT} = \sigma^1_{LS}$, $\sigma^1_{KT} = \sigma^1_{KS}$, and $\sigma^1_{3T} = \sigma^1_{3S}$. We further set $\sigma^1_{TS} = \sigma^1_{ST} = 10.00$ because evidence suggests that HEL and NEL are highly substitutable for one another (*11*). The substitution parameters in the nonfarm sectors are from (*1*).

We calculated the compensated demand elasticities, e_{ij}, i,j = 1,4, using the elasticities form of the Slutsky equation with estimates of uncompensated demand elasticities from (*5*) and the expenditure shares. The price elasticity of export demand, E_1, for agriculture is an intermediate-run elasticity taken from a review of the literature contained in (*7*).

Appendix table 1—Share parameter values

Parameter	Value	Parameter	Value
λ_{L1}	0.007	λ_{K1}	0.020
λ_{L3}	.336	λ_{K3}	.250
λ_{L4}	.657	λ_{K4}	.730
Θ_{L1}	.220	Θ_{L3}	.730
Θ_{K1}	.280	Θ_{K3}	.270
Θ_{T1}	.297	Θ_{L4}	.650
Θ_{S1}	.123	Θ_{K4}	.350
Θ_{31}	.080	Φ_T	.006
v_1	.009	Φ_S	.003
v_4	.722	Φ_1	.020

Appendix table 2—Elasticity values

Elasticity	Value	Elasticity	Value
σ^1_{LL}	−0.883	σ^1_{KL}	0.851
σ^1_{LK}	.851	σ^1_{KK}	−2.299
σ^1_{LT}	.204	σ^1_{KT}	1.215
σ^1_{LS}	.204	σ^1_{KS}	1.215
σ^1_{TL}	.204	σ^1_{SL}	.204
σ^1_{TK}	1.215	σ^1_{SK}	1.215
σ^1_{TT}	−6.240	σ^1_{ST}	10.000
σ^1_{TS}	10.000	σ^1_{SS}	−29.200
σ^1_{3L}	−1.622		
σ^1_{3K}	−.672		
σ^1_{3T}	2.987		
σ^1_{3S}	2.987		
σ^3_{LL}	−.185	σ^4_{LL}	−.269
σ^3_{LK}	.500	σ^4_{LK}	.500
σ^3_{KL}	.500	σ^4_{KL}	.500
σ^3_{KK}	−1.351	σ^4_{KK}	−.929
e_{11}	−.164		
e_{14}	.165	E_1	−2.000
e_{41}	.057		
e_{44}	−.126		
η_1	.376		
η_4	8.36		

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Output and Input Subsidy Policy Options in Bangladesh

Richard F. Nehring

Abstract. *Recent changes in pricing policies emphasizing price supports and phasing out fertilizer subsidies are a step in the right direction, particularly if minimizing the combined foreign exchange and budgetary expenditures of Bangladesh and donor nations is the key objective. A normalized restricted profit function is used to estimate profit and factor demand functions from farm-level, cross-sectional data for the food grain and jute crops in Bangladesh. The estimated elasticities are used to evaluate price support and fertilizer subsidy programs in terms of their costs to the government, foreign exchange effects, and producer surplus for the food grain and jute sectors.*

Keywords. *Food grains, jute, profit function, output price supports, fertilizer subsidies, elasticities, producer surplus, Bangladesh.*

Bangladesh has adopted food grain self-sufficiency as a national policy goal. Motives include the critical dependence of low-income consumers on adequate supplies of food grains, the need to boost agricultural incomes, and a desire to reduce foreign exchange outlays for food grain imports because of the limited scope for expanding exports. Bangladesh's past success in boosting food grain production at an annual rate of 2.5 percent between 1976 and 1988, coupled with its vast potential based on fertile soils and abundant supplies of labor and water, supports the feasibility of this strategy (*36*).[1] Although Bangladesh has made significant progress toward self-sufficiency since independence, wheat and rice imports remain large, having averaged close to 2 million tons per year during the 1980's (*27*, *38*).

The policy problem addressed in this article evaluates the shortrun effects of producer-oriented price support and fertilizer subsidy policies that support Bangladesh's goal of reducing dependence on food grain imports. The policies are evaluated against criteria of government cost, foreign exchange savings, and producer welfare. Other possible forms of public expenditure are not evaluated. A sustained longrun growth in food grain production is dependent upon improvement in irrigation, credit, transportation, flood control, and institutional factors, if combined with output and input price interventions. Shortrun pricing interventions that stimulate output along existing production functions, such as supporting product prices and subsidizing inputs, are important policy instruments in Bangladesh.

Both price support and input subsidies exist in Bangladesh. And, as in many other Asian countries, Bangladesh faces a tradeoff between policies that emphasize high input subsidies and low food grain prices on the one hand and those that emphasize low input subsidies and high food grain prices on the other (*10*, *20*). Increasing fertilizer prices by reducing fertilizer subsidies weakens the ability of Bangladesh to maintain food grain self-sufficiency under continuation of existing food grain security policies, which emphasize low food grain prices for consumers and minimal output price incentives to producers. Increasing fertilizer prices, by contrast, requires policymakers to raise food grain prices higher than before or to focus subsidies on other inputs, such as credit and irrigation, to encourage producers to invest in new technologies that boost production.

Food grain purchases have depleted foreign exchange reserves, exacerbated long-term balance of payments problems, dampened overall growth rates, and raised concern about the efficacy of price support and subsidized food grain distribution operations among the United States and other food donors. Although most imports are on concessional terms, commercial imports have become increasingly important in recent years. While net losses on food grains amounted to just $15 million in FY 1988, food budget subsidies soared to $200 million in 1989 due to higher import prices and record distributions of subsidized food grains (*36*). Food budget expenditures represented close to 8 percent of current expenditures during 1980-88 (*36*), and subsidized public food grain distributions continued on a large scale (*38*).

Government policies emphasizing fertilizer subsidies to encourage production have also raised questions among donors concerning the necessity and relative effectiveness of continuing large fertilizer subsidies. While fertilizer subsidies amounted to only $20 million in FY 1988, just one-fifth of the 1981 level, they increased sharply to $47 million in 1989 (*36*, *37*). Nitrogen fertilizer subsidies were phased out in 1986, but large per unit subsidies on phosphates and potash fertilizers persist (*27*). And, the slowdown in food grain production in recent years has revived the debate on the need for increasing nitrogen fertilizer subsidies (*36*).

Available analyses of price policy in Bangladesh are limited by lack of a comprehensive model of policy

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

evaluation and inadequacies in estimating key parameters measuring responsiveness of farmers and consumers to price incentives. This study focuses on measuring key parameters on the supply side and defining the costs and benefits of alternative pricing policies. The results should interest policymakers and analysts who face decisions about appropriate subsidy policies in other less-developed countries, and donors who are concerned with the impact of their aid and how supply responsiveness can affect trade forecasts.

Procedures for Policy Evaluation

Policymakers in Bangladesh generally accept the notion that government intervention in input and output markets is necessary to achieve food security objectives (*1, 7, 8, 10, 18, 20, 22, 24, 26, 33, 34*). Thus, controlling input and output subsidies is an important policy issue because food grain and input subsidies annually constitute a significant proportion of the Bangladeshi budget and potentially divert resources from programs with higher returns (*33, 36*).

Despite the importance of the output-versus-fertilizer subsidy issue in Bangladesh, there is clearly a lack of consensus on the relative impacts of the two policies. Tolley and others argue that the fertilizer subsidy policy is more expensive to the government than the output subsidy (*26*). Ahmed argues the opposite (*1*). With the continuing use of selected fertilizer subsidies to keep prices low for farmers, identifying how changes in the fertilizer subsidy will affect production remains an important issue. Research indicates that eliminating the fertilizer subsidy would not substantially reduce food grain output (*1*). In general, previous studies did not use econometric estimates of key parameters (for example, the own-price elasticity of output supply and the elasticity of output supply with respect to the price of fertilizer). Instead, they relied on best estimates of such parameters. Ignored are many of the competitive effects of key inputs (labor and animal power) and other outputs (wheat and jute).

The price support and input subsidy programs are evaluated for how a 1-percent increase in production influences government costs, foreign exchange savings, and producer welfare. Costs are measured for each program by using frameworks developed in other research (*1, 5, 6, 13, 18, 26*). The effects of each of the two programs on consumer welfare are limited because the prices of subsidized cereals are held constant, and distributed ration quantities are adjusted to help stabilize open market prices at current levels.

Effects of Higher Crop Prices

Increasing food grain production through higher price supports boosts government spending for procuring and handling the additional marketed supply of food grain and distributing procured food grains at subsidized prices to enforce the new support price. Outlays for already existing fertilizer subsidies rise as the higher crop price results in more fertilizer use. The net savings in foreign exchange associated with the price support program comes from the reduction in expenditures on food grain imports (as higher domestic production reduces import needs) minus the cost of larger fertilizer imports and the loss in revenues from jute exports.

It is assumed that food grain imports will be reduced by the 1-percent increase in production used in the evaluation of the output support and input subsidy programs. Fertilizer imports are assumed to continue to account for 40 percent of fertilizer consumption, which is comparable with the 1981-84 percentage. Wheat will likely continue to account for 83 percent of imports. Exportable supplies of jute will fall as higher food grain support prices lead to some diversion of jute area to rice. The price support program leads to a producer welfare gain which equals the additional revenues generated by the higher selling price, less the additional cost of inputs used to increase production. The government costs associated with higher price supports are also influenced by how much additional food grain must be procured and distributed at subsidized prices in order to prevent an increase in open market consumer prices. I assume that the government enforces the support price by purchasing all additional marketed surplus and distributing these quantities during the procurement period.

Farmgate prices were used in deriving the supply and demand estimates in the profit function analysis. Government policymakers have set support prices at the same level for all rice crops despite the disparate supply and demand conditions that prevail across the three cropping seasons (*33*). Winter rice has a lower price at the farmgate because of the impact on rice supplies that is caused by harvest of the large fall rice crop (*19*). The impact that these differences in prices have on procurement was factored into the analysis by weighting the average procurement levels separately for each food grain crop (*26*).

A constraint to stronger food grain price incentives is the desire of Bangladeshi policymakers to maintain an appropriate relationship between the prices of rice and jute (*19, 33*). Jute and rice compete for some of the same land, and jute exports account for a significant proportion of Bangladeshi export earnings (*27*). Half of the 600,000 hectares annually devoted to jute usually compete with the summer and fall rice crops, which together occupy about 9 million hectares (*19*). Given little reliable econometric evidence in the literature, the analysis arbitrarily assumed a cross-price elasticity of supply of 0.33 between rice and jute. The cross-price elasticity of supply between rice and other crops, including wheat, was ignored.

Effects of Higher Fertilizer Subsidies

Government costs associated with the fertilizer subsidy program include the cost of subsidizing the increased volume of fertilizer used by food grain and jute producers at the lower price, and the cost of producing and distributing enough of the additional marketed supply of food grains that are produced to maintain the existing support price. The net foreign exchange savings associated with a larger fertilizer subsidy match the reduced cost of food grain imports, plus the gain in revenues from larger jute exports, minus the cost of additional fertilizer imports. The change in producer welfare can be estimated as the additional revenues from selling the increased output, minus any change in costs resulting from using larger amounts of less expensive fertilizer. The fertilizer subsidy, I assume, causes the procurement volume to increase consistent with historical rates, leaving the support price unchanged. The quantity procured is therefore smaller than that for the price support program. Likewise, the market displacement effect, due to an increase in the quantity of rationed distributions, resulting in increased welfare to ration recipients for the fertilizer program, is likely to be less than for the price support program.

Gauging the responsiveness of Bangladeshi farmers to changes in crop and fertilizer prices is necessary to estimate the various program costs and benefits. Output supply and input demand elasticities have been estimated assuming profit-maximizing behavior by Bangladeshi farm firms producing food grains and jute. Well-behaved, normalized restricted profit functions are estimated, and supply and input response functions are derived. The profit functions for each of the food grains and jute were estimated separately.

The Profit Function Model

Diewert has suggested a translog form of the estimating equations for the normalized restricted profit function (*8*, *14*, *15*):

$$\ln G = \alpha 0 + \sum_{i}^{n} \alpha_i \ln V_i + 1/2 \sum_{i}^{n}\sum_{j}^{n} \gamma_{ij} \ln V_i \ln V_j \quad (1)$$
$$+ \sum_{i}^{n}\sum_{k}^{v} \delta_{ik} \ln V_i \ln U_k + \sum_{k}^{v} \beta_k \ln U_k$$
$$+ 1/2 \sum_{k}^{v}\sum_{t}^{v} \phi_{kt} \ln U_k \ln U_k + \sum_{d}^{r} \Theta_d D_d + e_i$$

$$\frac{\partial \ln G}{\partial \ln V_i} = \alpha_i + \sum_{j}^{n} \gamma_{ij} \ln V_j + \sum_{j}^{v} \delta_{ik} \ln U_k + e_i \ , \quad (2)$$

where G, the restricted normalized profit, is defined as total revenue less total costs of variable inputs normalized by P, the price of output; V_i is the price of variable input X_i, normalized by P; U_k is the kth fixed input; i, j=1,2,.... v are behavioral parameters (ln is the natural logarithm); α_0, α_i γ_{ij}, δ_{ik}, β_k, ϕ_{kt} are the behavioral parameters; and Θ_d is the coefficient of the dummy variable K accounting for r-1 regional differences and technical change. The profit functions for

Table 1—Descriptive statistics

Item	Unit	Spring rice	Summer rice	Winter rice	Wheat	Jute
Farm observations	(no.)	222	95	100	95	222
Variable profits	(taka)[1]	707.35	1,507.10	1,108.47	898.82	1,276.35
Output	(maunds of paddy, grain, or fiber)	16.89	27.64	23.30	18.25	10.45
Labor	(workdays)	48.74	70.45	42.22	44.24	65.82
Fertilizer	(seers of nutrients)	17.52	46.01	36.45	42.73	10.11
Animal power	(bullock teamdays)	16.23	19.87	12.18	10.60	9.71
Land cultivated	(acres)	.84	1.25	.66	.75	.63
Crop price	(taka/maund)	74.24	84.47	78.09	83.64	146.23
Wage rate	(taka/day)	10.42	9.73	12.97	10.34	9.56
Urea	(taka/seer)	1.51	1.50	1.52	1.50	1.56
Irrigation cost	(taka)	27.66	29.86	131.57	44.93	—
Bullock hire	(taka/team)	14.35	11.07	20.39	11.89	13.10
Fertilizer share[2]	(percent)	-.04	-.08	-.09	-.10	-.02
Labor share[2]	(do.)	-.74	-.42	-.56	-.46	-.62
Irrigation share[2]	(do.)	—	—	.09	.03	—
Tenants	(do.)	25.23	33.68	23.00	34.79	28.80
High-yielding varieties users	(do.)	27.03	11.58	70.00	100.00	40.90
Fertilizer users	(do.)	45.95	63.16	77.00	89.30	64.00

— = Not applicable.

Note: US$ = Taka 32.15 in 1988/89. One seer = 2.05 pounds. One maund = 82.29 pounds.

[1]Per farm actual variable profits, revenues from crop output and byproducts, less the cost of chemical fertilizer, hired labor, and irrigation.

[2]—Input quantity multiplied by input price equals profit.

Sources: (*28*, *29*, *30*, *31*, *32*).

wheat and winter rice were specified with three variable inputs: labor, fertilizer, and irrigation. The profit functions for summer rice, fall rice, and jute were specified with only labor and fertilizer. I measured the fixed inputs for each crop as the cost of capital (including the cost of hired bullock services, pesticides, seeds, organic fertilizer, and credit) and acres of land cultivated per farm.

Table 2—Parameter estimates

Variable	Spring rice	Summer rice	Winter rice	Wheat	Jute
α0	26.728	6.250	–1.138	2.386	2.865
	(3.869)	(1.879)	(.860)	(.502)	(2.928)
αF	–.213	.248	–.192	–.206	–.037
	(21.884)	(5.247)	(1.215)	(1.449)	(2.250)
αL	.965	.034	–1.410	.146	–.879
	(5.917)	(.034)	(3.928)	(.388)	(4.380)
αI			–.270	.198	
			(2.328)	(2.291)	
γFF	–.002	–.068	.047	–.025	–.016
	(.227)	(4.110)	(1.146)	(.798)	(1.748)
γLL	.169	–.169	–.323	–.346	–.490
	(1.163)	(9.632)	(3.198)	(7.742)	(10.284)
γII			.026	–.007	
			(1.733)	(.856)	
γFL	–.003	.049	–.145	.022	.033
	(.383)	(2.795)	(3.222)	(.768)	(3.614)
γFI			.003	–.003	
			(.214)	(.028)	
γLI			–.127	.048	
			(4.097)	(3.415)	
δFT	–.010	.011	.002	–.032	–.002
	(5.203)	(1.847)	(.074)	(1.532)	(.671)
δFK	.010	–.013	.011	.011	.009
	(5.193)	(2.693)	(.611)	(0.574)	(6.094)
δLT	.124	.093	–.049	.325	.174
	(1.652)	(4.820)	(.613)	(5.337)	(3.531)
δLK	–.146	–.114	.041	–.199	–.158
	(3.137)	(10.492)	(.789)	(3.386)	(5.631)
δIT			–.022	–.023	
			(.786)	(1.777)	
δIK			–.011	–.023	
			(.647)	(1.913)	
βT	6.782	–1.569	.464	2.380	2.311
	(4.269)	(1.687)	(.813)	(2.000)	(5.038)
βK	–9.496	1.215	.714	–.034	–.053
	(4.184)	(1.124)	(1.668)	(.023)	(1.897)
φTT	–.432	.026	–.145	.652	.330
	(2.420)	(.184)	(.843)	(3.062)	(2.044)
φKK	1.673	–.142	–.086	–.381	–.006
	(4.462)	(.811)	(1.036)	(.161)	(.107)
φTK	–1.104	–.054	.057	–.144	–.126
	(4.152)	(.394)	(.633)	(.780)	(1.882)
φBO				–.634	
				(12.415)	
θCO	1.763				
	(6.708)				
θDA	1.692				
	(6.543)				
θDI		–.222			
		(3.380)			
θFA	1.862				
	(7.254)				
θMY	1.260			–.118	
	(4.824)			(2.093)	
θNO		.201			
		(2.035)			
θJE				–.411	
				(7.633)	
θRA					–.017
					(.237)
θHYV			7.39		
			(10.557)		

Figures in parentheses are the absolute values of the asymptotic t-statistics.

Applying the Goldfield-Quandt test for heteroskedasticity between users and nonusers of fertilizer (implying, as seems reasonable, greater variance of profits for users), using OLS estimation, yielded F values of 2.20 with (103,103) degrees of freedom for spring rice and 3.93 with (40,40) degrees of freedom for summer rice. Thus, at the 0.5-percent level of significance, there is indication of heteroskedasticity for spring and summer rice. Consequently, all observations for spring and summer rice are divided by the standard errors of the separate regressions for users and nonusers of fertilizer prior to obtaining estimates shown in table 2.

The entire sample covered 9 regions: BO = Bogra, CH = Chittagong, DA = Dhaka, DI = Dinajpur, FA = Faridpur, JE = Jessore, MY = Mymensingh, NO = Noakhali, and RA = Rangpur. The regions covered for each crop are indicated by dummy variables reported above.

Seventy percent of winter rice producers reported using high-yielding varieties.

Information on Producer Surplus from the Restricted Profit Function

The welfare impact on producers of input and output price interventions in the associated input and output markets may be determined from supply and demand functions derived from the normalized restricted profit function (*13*, *18*). Producer welfare from such price changes may be analyzed by measuring producer surplus (PS), defined as the excess of gross receipts (TR) over total variable costs (TVC), PS = TR – TVC. Producer surplus is defined as the area above the supply curve and below the price line of the corresponding firm or industry (*13*). The welfare impact of a price change for a single input can be completely measured in the associated factor market, or the welfare impact of change for a single output can be completely measured in the associated output market, even though the price change induces a shift not only in output supply but other factor demands (*13*). All input markets for which prices are unchanged need not be considered in calculating the change in welfare.

The restricted profit function by definition represents producer surplus and may be used to derive the effect on producer welfare from government price interventions in input and output markets (*11*). The total change in producer surplus, $\Delta\Pi$, from initial output and input price (P^0, V^0) to final prices (P^1, V^1) may be expressed as:

$$\Delta\Pi = P^0 G(V^0, U) - P^1 G(V^1, U), \qquad (3)$$

which is the change in output-market producer surplus associated with the change in output price from P^0 to P^1, plus the sum of changes in the input market consumer surpluses associated with changes in the respective input prices from V_i^0 to V_i^1.

Derivation of Allen Elasticities from the Profit Function

The output effect may dominate the substitution effect for the profit function, obscuring the true relationships among the inputs. The defect may be remedied by expressing the compensated factor demand effects associated with changes in factor prices in terms derived directly from the profit function. Sakai showed that a factor demand's response to changes in output price, P, and input prices, V_j, can be decomposed as follows:

$$\frac{\partial_{X\,i}(V,U)}{\partial V_j} - \frac{\partial_X ({}_iV,Y,U^*,)}{\partial V_j} + \frac{\partial_X ({}_iV,Y,U^*)}{\partial Y}\,\frac{\partial_Y (V,U)}{\partial V_j}, \qquad (4)$$

where $X_i(V,U)$ is derived from the normalized restricted profit function using Hotelling's lemma, and embodies the substitution and profit-maximizing effects of an input price change (*16*, *21*). Y^* is the profit-maximizing level of output.

The Allen elasticity of substitution, in terms derived directly from the normalized restricted profit function, can be developed by manipulating the above decomposition. First, solve for the substitution effect. Second, convert the factor demand decomposition into an elasticity form and divide by factor j's contribution to cost. These two manipulations yield:

$$\sigma\, ij = \frac{\dfrac{\partial \ln Xi\,(V,U)}{\partial \ln vJ}}{\dfrac{V_j X^j}{C}} - \frac{\dfrac{\partial \ln X_i\,(V,Y^*,U)}{\partial \ln Y} \cdot \dfrac{\partial \ln Y\,(V,U)}{\partial Y \ln V_j}}{\dfrac{V_j X^j}{C}}. \qquad (5)$$

We can rewrite this as:

$$\sigma\, ij = \frac{-\dfrac{1}{p}\dfrac{\partial^2 G}{\partial V_i\,\partial V_j}}{-\dfrac{\partial G}{\partial V_i} - \dfrac{\partial G}{\partial V_j}} - \frac{-\dfrac{1}{p}\displaystyle\sum_{k=1}^{m}\frac{\partial^2 G}{\partial V_i\,\partial V_k}\quad \frac{1}{p}\sum_{k=1}^{m}\frac{\partial 2_G}{\partial Vi\,\partial V_k}\,V_k}{-\displaystyle\sum_{i=1}^{m} V_i \sum_{i=1}^{m}\frac{\partial^2 G}{\partial V_i\,\partial V_j\,\partial p}\,\frac{\partial V_j}{}\quad \frac{}{\partial V_i}\,\frac{\partial G}{\partial V_j}\,\frac{\partial G}{}}\, C. \qquad (6)$$

Letting $G_{ij} = \dfrac{-\partial^2 G}{\partial V_i\,\partial V_j}$; $G_i = \dfrac{-\partial G}{\partial V_i}$; $G_j = \dfrac{-\partial G}{\partial V_j}$;

$$Y_j = \frac{\partial Y}{\partial V_j};\quad Y_p = \frac{\partial Y}{\partial P};\quad G_{ip} = \frac{\partial^2 G}{\partial V_i \partial P},$$

and collecting terms, we can compactly write:

$$\sigma\, ij = \frac{G_{ij}}{G_i\, G_j} - \frac{G_{ip}\, Y_j}{Y_p\, G_i\, G_j}\, C, \qquad (7)$$

as our measure for the Allen elasticity of substitution, where C is the cost level for the profit-maximizing level of output. All elements can be derived from the profit function using Hotelling's lemma, and from information in the Hessian of the normalized restricted profit function, appropriately weighted by P and V.

Data, Estimation, Validation

The data used in this study were collected in 1978 by the U.S. Agency for International Development (USAID) in Dhaka in a sample survey of 222 farmers

growing summer rice, 95 farmers growing fall rice, 100 farmers growing winter rice, 95 farmers growing wheat, and 222 farmers growing jute. Analysts identified constraints on adoption of high-yielding varieties (*28, 29, 30, 31, 32*). Table 1 provides a description of selected variables, important in specifying the profit function models. Where appropriate, survey data, such as yields per acre, were compared with aggregate data. These checks suggested that the survey data are consistent with secondary data (*34*).

To estimate a profit function, farmers must face different vectors of prices (*12*). The data exhibit substantial variability in the input price variables, normalized by the output price and in the fixed inputs (*18*). The coefficients of variation of prices across farms are close to or greater than 10 percent for labor, fertilizer, and irrigation for all crops, and 7.9 percent for summer rice output, 11.1 percent for fall rice, 4.6 percent for winter rice, 3.3 percent for wheat, and 8.3 percent for jute. This variability suggests that the data may in some sense be suitable for estimation of parameters econometrically and for computing price and other elasticities. Although some price variability may be due to transport or other costs, farmers producing each crop still face the same production functions. They are competitive within geographically distinct locations where prices are significantly related to the state of development of infrastructure (*3*). Nonprice factors, such as soil and climatic differences, are accounted for in district dummies. Nonparametric tests for profit maximization also support the profit function approach (*9, 18*).

The system of profit and share equations in equations 1 and 2 were estimated using the iterative, seemingly unrelated, regression method (*25*). Symmetry and parametric constraints were imposed in estimating the parameters of the profit and input demand equations. The monotonicity and convexity conditions were satisfied at the means of the data. Estimated own-price elasticities were computed using simple averages of input shares at the sample means of the independent variables (*23*). Allen own- and cross-price elasticities of substitution were computed as shown in equations 4-7.

All own-price effects shown in table 2 are in accord with the usual hypotheses on sign, and most are statistically significant, and therefore useful for predicting adjustments to changes in price and exogenous variables and in formulating government policy. Table 3 indicates that food grain and jute supply are positively related to increases in the price of rice and exogenous increases in land quantity and the input of capital, primarily bullock power, and are quite inelastic with values substantially less than 1.0, though less inelastic than the 0.10- to 0.25-range suggested by the work of other researchers (*1, 2, 20, 26*). The own-price elasticities of supply are also much higher relative to the elasticity of supply with respect to fertilizer price than reported by other researchers (*11, 26*). Food grain and jute supply are negatively related to increases in the price of each of the variable inputs.

The effectiveness of higher price supports depends largely on how responsive producers are to a change in price, or the crop's own-price elasticity of supply. The higher the supply elasticity, the greater the output response and the smaller the price increase needed to evoke a given change in production. The estimated own-price elasticities of supply shown in table 3 range from 0.371 for jute to 0.877 for summer rice. The result for summer rice is contrary to *a priori* expectations that relatively traditional crops exhibit low supply elasticities. However, among the food grain crops, the response to output price, at 0.406, is lowest for the fall rice crop, the most traditional crop, and, at 0.473, next to highest for the most commercialized food grain crop, winter rice. Thus the results are generally close to what one would expect *a priori*. The reported elasticities are relatively inelastic (*20*). The impact on output of an adjustment in the procurement prices is adjusted using Ahmed's results, which indicate that a 1-percent increase in procurement price results in a 0.85-percent increase in output price (*2*).

The effectiveness of the fertilizer subsidy program depends primarily on the size of the elasticity of output supply with respect to the fertilizer price. The more negative the elasticity, the less fertilizer prices have to be reduced to stimulate a given increase in output. The elasticities of output supply with respect to the fertilizer price range from –0.032 for jute to –0.097 for wheat, indicating that crop production is largely unresponsive to a change in fertilizer price alone (table 3). And, comparison of the crop own-price elasticities with those for outputs with respect to fertilizer prices indicates that producers generally respond more strongly to crop price changes than they do to changes in fertilizer prices.

The costs of supplying additional fertilizer to farmers are determined by the degree to which farmers change their use of fertilizer as fertilizer prices change. These elasticities range from –0.218 for fall rice (the least commercialized crop) to –1.529 for winter rice (the most commercialized crop), indicating significant variability in the extent to which producers of different crops respond. These are results one would expect *a priori*. The changes in fertilizer use resulting from a change in crop price are measured using the elasticity of fertilizer demand with respect to the output price. For food grains, these elasticities range from 1.049 for winter rice to 1.554 for wheat and indicate that fertilizer use is relatively responsive to changes in crop prices.

The results indicate that a fertilizer subsidy can stimulate an increase in production in the short run. However, the complementarity between fertilizer and irrigation in winter rice production in table 3 suggests that sustained long-term growth depends on an im-

Table 3—Elasticity estimates for supply and demand for variable and fixed inputs of food grain and jute production

Item	Price of output	Price of labor	Price of fertilizer	Price of irrigation	Land	Capital
Output supply:						
Summer rice	0.877	−0.838	−0.039	—	0.456	0.817
Fall rice	.406	−.340	−.066	—	.934	−.012
Winter rice	.473	−.342	−.063	−0.069	.901	.119
Wheat	.437	−.289	−.097	−.074	.607	.240
Jute	.371	−.339	−.032	—	.999	.456
Labor:						
Summer rice	2.010	−1.972	−.038	—	.254	.927
Fall rice	1.213	−1.018	−.196	—	.782	.174
Winter rice	.984	−1.165	.108	.072	.939	.079
Wheat	.991	−.716	−.147	−.152	.073	.539
Jute	2.413	−.825	−.075	—	.822	.621
Fertilizer:						
Summer rice	1.192	−.674	−.994	—	.758	.053
Fall rice	1.259	−1.040	−.218	—	.863	.068
Winter rice	1.049	.626	−1.529	−.148	.846	.044
Wheat	1.554	−.685	−.847	−.045	1.980	.221
Jute	.906	−2.118	−.295	—	1.195	−.044
Irrigation:						
Winter rice	1.080	.541	−.138	−1.336	1.046	.141
Wheat	2.435	−2.160	−.093	−.902	1.254	.588

— = Not applicable.

provement in irrigation infrastructure because high-yielding varieties are dependent on irrigation for efficient use of fertilizer (*3*, *33*, *36*). These elasticities, however, involve producer adjustments of output levels and input levels in response to output and input price changes and are not the input substitution along an isoquant. By separating the substitution and expansion effects, I can provide this information and estimate the substitution effects in the Allen elasticity sense directly from the profit function (*16*).

The Allen own-price elasticities in table 4 imply the following conclusions. All have the correct sign. Labor demand seems to be very inelastic, as one would expect in a country like Bangladesh with low wages and surplus agricultural labor. However, the factor demand decompositions reveal that the total negative effects of a change in wages on the demand for labor are elastic, but are only slightly larger than the positive effects of profit maximization due to a change in the price of labor. In general, fertilizer and irrigation demand appear to be very elastic, reflecting the growing use of modern inputs.

The Allen cross-price elasticities present a mixed picture (table 4). Strong substitutability seems to exist between the labor-fertilizer pair in the production of summer and winter rice. Very little interaction appears to exist in wheat and jute production. A strong complementarity between the labor-fertilizer pair is suggested only in the production of spring rice. These are noteworthy results. Bangladesh, characterized by severe underemployment, may not have to pay a high price in employment if it raises fertilizer prices to reduce fertilizer subsidies. This relationship can perhaps be partly explained by the use of hired labor and animal labor to produce and apply manure. Therefore, an increase in the fertilizer price gives farmers an incentive to substitute manure for chemical fertilizer, and to hire the labor needed to produce and apply it.

Prices significantly influence farmer demand for fertilizer, although nonprice factors such as irrigation and credit availability are undoubtedly important. Thus, one of the ways the government may influence demand for fertilizer is by the fertilizer and output price policies it follows.

Table 4—Allen elasticities

Factors	Labor	Fertilizer	Irrigation
Labor:			
Summer rice	−0.050	−0.793	—
Fall rice	−.004	1.375	—
Winter rice	−.392	1.320	0.987
Wheat rice	−.412	−.057	3.937
Jute	−.004	.096	—
Fertilizer:			
Summer rice		−23.422	—
Fall rice		−.094	—
Winter rice		−8.184	−.118
Wheat		−2.266	6.514
Jute		−2.677	—
Irrigation:			
Winter rice			−5.556
Wheat			−59.489

— = Not applicable.

Analysis of Policy Alternatives

Incremental cost calculations require base-level estimates of several variables. Averages of crop production, crop prices, and fertilizer prices for FY 1979-81 are taken as the base level (table 5). However, numerous changes in 1979-81 base variables occurred in recent years. World fertilizer prices fell close to 15 percent during the early 1980's compared with the late 1970's. At the same time, to fulfill its goal of reducing subsidies, the government increased fertilizer prices to farmers by more than 60 percent (*19*). On average, world food grain and jute prices fell nearly 20 percent. Government-subsidized prices of rice and wheat were raised to achieve a closer alignment with procurement prices, eliminating some of the consumer subsidy historically provided for ration recipients. Significant changes in fertilizer use among crops occurred: use on wheat and winter rice rose relatively; while use on summer rice, fall rice, and jute fell relatively. These changes in variables are recorded in table 6.

Given the estimated elasticities, a 1-percent increase in total food grain production can be expected to result from a 2.22-percent increase in rice support prices for all three crops, coupled with a 2.69-percent increase in wheat support prices, or a 16.20-percent drop in fertilizer prices to food grain and jute producers. The estimated incremental government costs, net foreign exchange savings, and changes in producer welfare associated with using price support and fertilizer subsidy programs to stimulate a 1-percent increase in food grain production are computed following a variation of the model described in (*26*, pp. 139-62). The base results indicate that the major differences between the two programs are in the areas of government costs and foreign exchange savings (table 7). The budgetary cost of the fertilizer subsidy program is about 11 percent lower than the cost of the price support program (primarily because issue prices are reduced 8 percent to compensate consumers for welfare losses due to higher price supports), while producer welfare gains are only slightly higher for the fertilizer subsidy program. The net foreign exchange savings are, on the other hand, 17 percent higher for the price support program. Based on these criteria, and particularly if minimizing combined foreign exchange and budgetary cost is a key objective, enhanced price supports may be the better policy option for stimulating production for Bangladesh.

Table 5—Estimated base level of variables used in analysis, FY 1979-81 averages

Crop	Procurement/distribution							Fertilizer		
	Production	Procurement	Domestic price support	Trade price	Handling cost	Issue price	Market surplus	Use	Farm price	World price
	---*1,000 tons*---		----------------*Dollars/ton*-------------------				*Percent*	*1,000 tons*[1]	--*Dollars/ton*--	
Rice:										
Summer	3,161	36	255	363	40	211	25	74	298	539
Fall	7,643	299	255	363	40	211	25	140	298	539
Winter	2,352	130	255	363	40	211	50	15	298	539
Wheat	803	116	176	197	40	162	50	15	298	539
Jute	1,033	—	214	383	40	—	80	22	296	539

— = Not applicable.
[1]Nutrient tons of nitrogen, phosphates, and potash.
Source: (*11*).

Table 6—Estimated base level of variables used in sensitivity analysis, FY 1982-84 averages

Crop	Procurement/distribution							Fertilizer		
	Production	Procurement	Domestic price support	Trade price	Handling cost	Issue price	Market surplus	Use	Farm price	World price
	---*1,000 tons*---		----------------*Dollars/ton*-------------------				*Percent*	*1,000 tons*[1]	--*Dollars/ton*--	
Rice:										
Summer	3,185	11	237	311	50	228	25/30	81	344	458
Fall	7,600	99	237	311	50	228	25/30	173	344	458
Winter	3,366	93	237	311	50	228	50/85	144	344	458
Wheat	1,087	55	151	195	50	158	50/85	27	344	344
Jute	892	—	211	303	50	—	80	14	344	458

— = Not applicable.
[1]Nutrient tons of nitrogen, phosphates, and potash.
Source: (*11*).

Sensitivity of Results

Results are highly sensitive to the base levels used for marketable surplus, procurement level, domestic prices, and import prices of crops and fertilizers. This will be demonstrated in the policy scenarios that follow.

To calculate the impact of such changes on government cost, foreign exchange savings, and producer welfare due to a 1-percent change in output induced by price supports or fertilizer subsidies, the model was re-evaluated under six additional scenarios, incorporating variables from a 1982-84 base (table 7). To simplify the analysis, the initial price elasticities were left unchanged, although the elasticity estimates are likely to be biased (*18*). All scenarios using 1982-84 food grain prices reflect the government's current policy to more closely align issue and procurement prices:

- Scenario one: the model was re-evaluated using 1979-81 base level values for all variables except for fertilizer prices, which were set at 1982-84 levels.

- Scenario two: only food grain prices were set at 1982-84 values.

- Scenario three: both fertilizer and food grain prices were set at 1982-84 values.

- Scenario four: the model was re-evaluated, incorporating variables using 1982-84 as a base, assuming a 35-percent upward adjustment in nonfertilizer input prices to reflect input price trends (*27*, *36*).

- Scenario five: the basic model for 1982-84 was re-evaluated, allowing for increases in marketable surplus and procurement. This scenario assumes that implementation of a more effective price support program may raise the level of marketable surplus because maintenance of previous price levels, as assumed for both programs, may require an upward adjustment in procurement levels. I assumed that marketable surplus for wheat and winter rice, induced by an effective price support program, was 75 percent compared with the previous 50 percent, and 30 percent for summer and fall rice compared with the previous 25 percent. In this scenario, I assumed that procurements would constitute 10 percent of the food grain crop, rather than the lower historical levels. In scenario six (not shown in table 7), the model was re-evaluated using 1982-84 as a base but using the actual cost of fertilizer. As stated previously, the government does not pay world market prices for fertilizer.

Results

Scenario one (current fertilizer prices): the new assumptions do not alter the initial conclusions pertaining to the 1979-81 base case. The budgetary cost of the price support program remains lower than for the fertilizer subsidy program, but the advantage is narrowed. At the same time, the level of producer welfare gains increases sharply for both programs. These results are as expected. An increase in price supports or fertilizer subsidies, as higher domestic fertilizer prices and lower world fertilizer prices, implies relatively lower economic subsidies and higher producer welfare gains compared with the base case. Foreign exchange savings, which are more strongly influenced by changes in world grain prices than fertilizer prices, remain slightly higher for the price support program.

Scenarios two (higher food grain prices) and three (higher food grain and fertilizer prices): the new assumptions improve the producer welfare advantage for the fertilizer subsidy program, and substantially so in scenario three. Budgetary results remain basically unchanged compared with the 1979-81 base case. Net foreign exchange savings, because of higher food grain prices, are drastically reduced for both programs. In scenario two, real input prices of all inputs decline sharply, leading to higher producer surpluses for most crops as the result of price supports or fertilizer subsidies. The major crop-specific changes for scenarios two and three compared with the 1979-81 base case are large gains in producer welfare for summer rice producers under the fertilizer subsidy program, and a reduction in producer welfare gain for winter rice producers under the price support program.

Scenario four (base level, 1982-84): producers realize a slight welfare advantage for the price support program compared with the 1979-81 base case. The foreign exchange advantage of the price support program also improves. In this scenario, reduced food grain and fertilizer prices imply reduced foreign exchange expenditures, although this factor is offset partially by higher base-level food grain production and, therefore, a somewhat larger food grain import requirement. The level of producer surplus resulting from a 1-percent change in production remains close to the 1979-81 base levels, reflecting increases in the real price of inputs offsetting increases in output price.

Scenario five (price support adjustment, 1982-84 base): the new assumptions enhance the producer welfare advantage of the price support program compared with the 1982-84 base case because of the assumed increase in marketable surplus (which influences costs only in the price support program). The new assumptions also drastically raise the budgetary cost of the price support program, which is now only 32 percent lower than the fertilizer subsidy program. Producer

Table 7—Estimated benefits and costs of price support and fertilizer subsidy programs in Bangladesh[1]

Scenario	Summer rice		Fall rice		Winter rice		Wheat		Jute		Total	
	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy
Base level 1979-81:												
Government cost increase	3.9	7.4	6.0	9.1	3.8	13.1	1.4	1.7	—	1.4	15.1	32.7
Foreign exchange savings	12.2	2.0	12.5	17.5	4.3	–.2	1.7	2.4	2.8	1.8	27.9	23.5
Producer welfare gain	2.5	2.4	5.6	9.8	6.3	3.0	1.0	.3	–.8	.3	15.5	15.8
Current fertilizer prices:												
Government cost increase	3.7	6.5	5.6	9.6	3.5	10.7	1.3	1.6	—	1.4	14.1	29.8
Foreign exchange savings	11.5	2.3	12.6	17.7	4.3	.6	1.7	2.5	–2.8	1.9	27.3	25.0
Producer welfare gain	1.9	2.2	5.9	10.1	19.7	15.3	1.3	.4	–.8	.5	28.0	28.5
Current grain prices:												
Government cost increase	4.1	7.3	6.2	9.2	4.1	13.1	.9	1.7	—	1.4	15.1	32.7
Foreign exchange savings	9.2	3.1	10.0	13.7	3.4	–1.2	1.3	1.9	–2.7	1.8	21.2	17.3
Producer welfare gain	4.0	3.6	10.0	15.1	3.1	2.8	2.0	—	–.8	.3	18.3	21.8
Current fertilizer and grain prices:												
Government cost increase	4.0	6.5	5.8	9.6	3.7	10.8	1.3	1.2	—	1.4	14.8	29.5
Foreign exchange savings	9.2	1.5	10.1	14.1	3.4	–.4	1.4	1.9	–2.7	1.9	21.4	19.0
Producer welfare gain	3.7	3.4	9.0	17.0	3.4	3.7	1.9	.1	–.8	–.5	17.2	24.7
Base-level 1982-84:												
Government cost increase	4.0	6.7	5.0	10.3	5.0	14.0	1.4	2.3	—	.8	15.4	34.1
Foreign exchange savings	10.0	1.3	9.9	13.6	5.0	–.2	1.8	2.4	–1.9	1.2	24.8	18.3
Producer welfare gain	3.2	2.8	6.2	9.7	6.2	2.2	1.9	.1	–.8	.9	16.7	15.7
Price support adjustment:												
Government cost increase	6.1	7.1	8.8	12.3	8.2	14.7	2.2	2.4	—	.8	25.3	37.3
Foreign exchange savings	10.0	1.3	9.9	13.6	5.0	–.2	1.8	2.4	–1.9	1.2	24.8	18.3
Producer welfare gain	3.9	3.4	7.5	11.6	9.3	3.3	2.9	.2	–.8	.9	22.8	19.4

— = Not applicable.

[1]Estimated incremental costs and benefits of inducing a 1-percent increase in total food grain production through each policy.

welfare results in both scenarios four and five are dominated by changes within the summer rice and winter rice crops.

Scenario six (cash flow, 1982-84): the budgetary cost advantage of the price support program is not appreciably altered even though increases in costs for fertilizer are now based on actual costs to the government rather than donor costs. The largest component of change in fertilizer costs (increased costs of subsidizing existing volume) consists of increased subsidies on domestic production and reduced revenues on imported fertilizers and remains unchanged compared with the 1982-84 base. The assumption of actual costs indicates, however, that the price support program has no advantage over the subsidy program in terms of foreign exchange savings compared with the 1982-84 base.

The government may not need to procure as much food grain under the fertilizer subsidy program to support the output price, which could fall due to a decline in fertilizer price. To evaluate this assumption, procurements under the fertilizer subsidy program were reduced 20 percent for both the 1979-81 and 1982-84 base cases. The results indicate that costs to the government for the fertilizer subsidy program fall less than 2 percent in the 1979-81 base case and less than 1 percent in the 1982-84 base case. Changes in subsidy costs due to increased fertilizer consumption are clearly much larger than costs related to larger procurements.

The results of using more current fertilizer and food grain prices suggest that recent drops in world fertilizer and food grain prices either reduce or remove the cost advantage of the fertilizer subsidy program but improve the producer welfare advantage of the program. In the case of either current food grain or fertilizer prices, the price support program has an advantage over the input subsidy program.

Conclusions

This analysis shows that changes in the procurement prices for food grains have a relatively greater impact on output supply and input demand than do changes in the level of fertilizer subsidies, and, given the current levels of output prices and input subsidies, output price supports may involve somewhat higher foreign exchange savings and slightly less government spending than fertilizer subsidies to induce the same percentage impact on output. The two programs appear to be largely neutral in terms of producer welfare. Although the total costs of the two programs are very similar, enhanced price supports may be the better policy option for stimulating production, particularly if reducing the combined foreign exchange and budgetary costs of Bangladesh and donor nations is a key goal. Clearly, the government faces a difficult policy choice between fertilizer subsidies and price supports on the basis of criteria evaluated in this article.

Although these results should be interpreted cautiously given the limitations of the cross-section data used, they seem to suggest that shortrun food grain supply elasticities in Bangladesh may be somewhat higher than previously thought (*1*, *11*). More recent results support these conclusions. Using 1982 for 330 farms, Ahmed and Hossain (*3*) estimated a Cobb-Douglas profit function specified with output measured as variable profits from crops, livestock, and other income, labor and fertilizer as variable inputs, and capital and land as fixed inputs. The results on all variables are highly significant and imply an output elasticity with respect to price of 0.56 and an own-price elasticity of demand for fertilizer of –1.12. However, nonprice factors, including technological change and increases in irrigation inputs, have played a large role in boosting Bangladesh's production of food grains in recent years. Ideally, one would estimate a multi-output profit function from panel data collected over a period of years. A profit function analysis using a time series cross-section data set could more completely capture how producers, given the technology, adjust output and input levels in response to price changes. Nonetheless, with all its limitations, the profit function analysis used in this study (which included irrigation in the specifications for winter rice and wheat and high-yielding varieties in the specification for winter rice) appears to have captured a significant response to price changes.

The availability of donated imported fertilizer that can be resold at a higher price to farmers makes the fertilizer subsidy program attractive to the Government of Bangladesh because most costs are actually incurred by donors. In fact, revenue generation from the sale of donated fertilizer has made it easy for the government to maintain a high level of subsidy on fertilizer by keeping prices low, thereby achieving popular support by passing a part of the grant to farmers. The revenues received from resale of concessional food grain imports, in contrast, are not sufficient to produce an overall net surplus on the food account. Therefore, an increase in price supports raises government costs. Disaggregation of the budgetary and foreign exchange costs of the two programs into costs paid by the government and costs paid by donor nations is a worthwhile topic for more research.

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A Note on the Value of the Right Data

Michael Martin and Ali Emami

Author's note: *From time to time, we forget that the data we use are at least as important as the methods we employ. True, agricultural economists have devoted considerable effort to assessing and understanding the appropriate application of theory, underlying assumptions, models, and methodologies for estimating elasticities. And, this has led to real progress in the analysis of international commodity markets. But, data are what we seek. Methodology and procedures lead us nowhere without the right results.*

Over the years, a number of observers, including Orcutt, Parniczky, and Griliches, have cautioned that inconsistencies are often present in trade data (*5, 1, 6, 4*).[1] We have joined Hueth in believing that traded quantities reported by agricultural exporters consistently exceeded quantities reported by importers (*2*). We wanted to find the possible causes of these observed inconsistencies and the implications, in terms of elasticity estimates, of using exporter versus importer trade data.

Causes and Consequences of Data Inconsistencies

There are, of course, several explanations for inconsistencies in international trade data. When trade is evaluated in value terms, differences in exchange rates, trade terms (FOB—free on board, CIF—cost insurance freight), timing of discharge and receipt, and discounts or rebates may all contribute to inconsistencies among trade levels reported by exporters and importers.

Inconsistencies are more difficult to explain for trade volumes. One or both of the trading partners may simply have collection and reporting processes or procedures which perform poorly. In some instances, certain countries may underreport imports, overstating self-sufficiency for political reasons. Ely and Parniczky say the exporter is frequently unaware of the final destination of the merchandise, and the importer has several choices in identifying the country of origin.

Japan, for example, is notorious as a re-exporter in agricultural trade. While exporters may be aware of this, they may be unable to correct the data to fully reflect re-export activities. Using Japan as an example, we hypothesize that import demand for certain commodities is:

$$Mj^et = Mj^ct + Mj^rt,$$

where:

Mj^et is the total quantity exported to Japan from, say, the United States in period t,

Mj^ct is the quantity actually consumed in Japan in period t (or possibly t + 1),

Mj^rt is the quantity purchased and re-exported by the Japanese in period t (or t + 1).

In this case, Mj^ct is a function of all the standard import demand variables, such as real price, real income, prices of related goods, population, and exchange rates. However, Mj^rt is likely to be a function of an entirely different and possibly unrelated set of variables.

If an exporter country, say the United States, reports sales to Japan as Mj^et, as though $Mj^et = Mj^ct$, then elasticities estimated using these data will be incorrect. To obtain true elasticities, Mj^ct, as reported by Japan, should be utilized. It can easily be shown that, in general, the larger the share of resale related to total traded quantity (Mj^rt/Mj^et), the more the own-price elasticity (estimated using inaccurate exporter data) will be biased toward underestimation of the true elasticity. That is, estimates using exporter data will yield elasticities more price inelastic than the "true" elasticity. To obtain "true" elasticities, Mj^ct, as reported by Japan, is the correct data source. A simple example: assume the importer, Japan, re-exports a consistent percentage, γ, of their imports ($0<\gamma<1$). The exporter, the United States, does not account for this re-export. Thus, its data assume all sales, $Q^*_M = Q_M + \gamma Q_M$, where Q_M is the true quantity consumed in Japan. Now, assume demand in Japan can be defined as:

$Q_M = \alpha - \beta P$, then the "true" price elasticity of demand, in absolute terms, is:

$$\epsilon = \beta \cdot \frac{P}{Q_M}.$$

However, a model using U.S. data is specified as:

$$Q^*_M = \alpha - \beta P,$$

$$\text{or} \quad Q_M + \gamma Q_M = \alpha - \beta P,$$

$$\text{or} \quad Q_M = \frac{\alpha}{1+\gamma} - \frac{\beta}{1+\gamma} P.$$

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

The elasticity (in absolute terms) estimated here is:

$$\frac{P}{Q_M} > \frac{P}{Q^*_M}.$$

We know $\beta > \frac{\beta}{1+\gamma}$ and $\epsilon^* = \frac{\beta}{1+\gamma} \cdot \frac{P}{Q^*}$. Clearly, therefore, $\epsilon^* < \epsilon$ (in absolute terms).

A Specific Case

As an illustration of the effect of data inconsistencies or inaccuracies on estimates of demand and demand elasticities, we carried out a simple exercise. We selected a published demand model that used exporter data for the dependent variable. We then re-estimated the model using importer data for the dependent variable with original independent variable data. More specifically, we re-estimated the demand for U.S. wheat in the Japanese market, choosing the Gallagher, Lancaster, Bredahl, and Ryan model because: (a) it has been widely cited, establishing credibility, (b) its research was sponsored by USDA, (c) it is an easily replicated, single-equation OLS estimate, and (d) its entire data set is under one cover (*3*).

The model is:[2]

$$\frac{WXCJ}{POPJ} = \text{Constant} - b\,\frac{(RPWJ)}{(CPIJ)} - c(YCPJ) - d(QWSJ)$$
$$-f(DSTRIKE),$$

where:

WXCJ = Commercial exports of U.S. wheat and flour to Japan (million bushels),

POPJ = Japanese population (millions),

RPWJ = Japanese Food Agencies (JFA) wheat resale price (yen/kg.),

CPIJ = Japanese consumer price index (1970 = 1.0),

YCPJ = Per capita consumption expenditures (real) in Japan (1970 = 1.0),

QWSJ = Wheat production and beginning stocks in Japan (million metric tons), and

DSTRIKE = Dummy variable for West Coast dock strike.

For the purpose of this example, we simply substitute variable WMCJ for WXCJ, where:

WMCJ = Commercial imports of U.S. wheat and flour by Japan as reported by the JFA.

[2]According to (*3*), this is the "best of several alternative equations."

Table 1—Comparison of OLS demand coefficients for U.S. wheat in Japan, based on different sources for dependent variable data, 1960-74

Variable	WXCJ	WMCJ
Constant	2.0751	1.8349
RPWJ/CPIJ	–.0018	–.0022
(t-stat)	(2.87)	(2.01)
VCPJ	–23.5319	–11.0262
(t-stat)	(.77)	(.20)
QWSJ	–17.2810	–.0315
(t-stat)	(2.53)	(.29)
DSTRIKE	–.0749	.0112
(t-stat)	(3.88)	(.38)
R^2	.930	.842

Table 2—Comparison of estimated demand elasticities for U.S. wheat in Japan, based on different sources of dependent variable data, 1960-74

Elasticity	WXCJ	WMCJ
Price	–0.97[1]	–1.31[1]
Income	–.33	–.13
Japanese production	–.43[1]	–.08

[1]Statistically significant at the 95-percent level.

During the model's analysis (1960-74), the volume of U.S. wheat exported to Japan exceeded JFA-reported volumes of U.S. wheat imports by an average of 4 percent per year.[3] As suggested earlier, there are several possible explanations for this difference. It seems reasonable to conclude, however, that at least a share of this discrepancy can be attributed to Japanese re-exports of wheat.

The WXCJ demand estimate assigned responses to Japanese consumers, which were, in fact, partly responses by consumers in other (re-export) markets. The discrepancy in the data led to a misspecification of the model. The "true" Japanese demand coefficients could have been more accurately captured in the alternative WMCJ model.

Table 1 compares the estimated coefficients from the two models. Table 2 compares the estimated elasticities computed at the mean. The results are revealing but not surprising. As expected, demand estimates using JFA data were more price elastic. The other variables in the WMJC model were not statistically significant.

If the WMCJ model had been more appropriate, we could conclude the following:

- Japanese consumers were more sensitive to U.S. wheat price than reported by the model, and

[3]Clearly, these are old data. However, comparisons of USDA and JFA reports reveal that these discrepancies in reported trade volumes still exist in the data.

- Much of the variation in U.S. exports attributed to Japanese income growth and changes in Japanese wheat production, in fact, resulted from Japan's wheat re-export activities.

We do not seek to find fault with the model in (*3*). The choice of data was probably correct and the model accurate. Our intention is to demonstrate that inconsistencies in data can lead to substantial differences in analytical outcomes and policy recommendations.

Conclusion

Fully understanding the data is important, essential to conducting international agricultural demand analysis. Although this may seem obvious, the data trail may be lost in the rigors of econometric estimation.

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A Comment on the Role of Professional Journals in Facilitating Data Access

Douglas L. Young

Author's note: *The scientific community is increasingly concerned about the availability and accuracy of data and procedures underlying published scientific research. The Board and editors of* The Journal of Agricultural Economics Research *(JAER) recently decided against requiring its authors to furnish access to ready-to-use data in published articles, but they encourage such access. In May 1990, the* American Journal of Agricultural Economics *urged authors to make their procedures and data available to other researchers for purposes of replication but stopped short of requiring such sharing.*

I favor open access to data and methodology used in published scientific research. The *Western Journal of Agricultural Economics* (WJAE), on which I have served as co-editor for the past 3 years, enforces a data access policy. The WJAE experience may be of particular interest to the JAER audience because USDA employees who submit articles to WJAE and who have used confidential government data have been, to date, the only authors encountering difficulty with the WJAE policy.

Only a handful of economics professional journals, including the *Journal of Applied Econometrics* (JAE), the *Journal of Econometrics*, the *Journal of Money, Credit, and Banking* (JMCB), and WJAE, require access to data and methodology prior to reviewing submitted articles. Given the integral role of careful documentation and openness in the scientific method, it is surprising that these requirements have been occasionally controversial for the few journals that have enacted them. After all, scientific verification or refutation of research results is impossible if the methodology and data are unavailable or too vaguely documented to reconstruct.

Careful documentation and access to data are important because science is a cumulative process. The process is most efficient when researchers can confirm that the earlier results upon which they are basing their inquiries are sound. A sound base of verifiable research should reduce the number of false starts and dead-end hypotheses. Insistence on replication is an important safeguard for the foundations of any science (*1, 5*).[1]

Concern about possible errors in published research results due to errors in the data and/or methodology is well founded. In a landmark study published in the *American Economic Review*, Dewald, Thursby, and Anderson found that errors in published research articles due to data transcription errors, computer programming mistakes, and related "data problems" were relatively common (*3*). This conclusion was based upon an ambitious project to replicate empirical results of several articles published in JMCB.

Openness in the sharing of data and methodology also fosters efficiency in the use of scarce and costly data. At the time the research is conducted, researchers often can store the data and methodology for future use at a low marginal cost.

Insistence by professional journals that authors provide access to their data can help encourage flexibility and openness in government agencies that collect data. Data access policies provide motivation for working out compromise solutions to the conflicting but mutually important requirements of confidentiality and access with respect to government data.

WJAE Policy

WJAE is the only agricultural economics journal in North America that makes consent to data access and documentation a formal condition for entering the review process. Since January 1, 1988, authors submitting manuscripts to WJAE must consent to document fully their procedures and "to make data used available at cost upon request for five years."

On the whole, the policy has worked smoothly. Most authors have agreed routinely to the data and estimation policy. Since July 1988, authors of only three manuscripts were unable to comply at first. All three cases involved USDA authors who had used confidential government data. One of these cases, which involved Department of Commerce agricultural census data as well, was resolved by a compromise. The other two, involving USDA survey data, were eventually withdrawn due to failure to reach a timely compromise, but ongoing negotiations may yet achieve a long-term solution.

The government is justified in legally restricting access to some observations from private citizens. The key component of the successful compromise with WJAE asks an authorized government employee acting as a third party to obtain requested aggregated statistical results from the confidential data set. These results are provided to the requester through the editors of WJAE. This compromise meets the spirit of

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[1] Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

WJAE's data access policy. It complies with census and USDA confidentiality requirements that forbid divulging information on individual respondents or even on small groups of respondents (2). The WJAE compromise essentially substitutes "reasonable access to aggregated results" for "access to the raw data."

USDA's initial proposal for providing access to the data in the two as yet unsuccessful cases was burdensome. USDA proposed an extensive application and internal review process for anyone requesting access to confidential USDA data used in the potential WJAE articles. Once the application cleared that hurdle, USDA would have required the applicant to obtain the data personally in Washington, DC.

This proposal was rejected by the Western Agricultural Economics Association because both the uncertainty of access and the formidable practical barriers were judged to violate the spirit of the access policy. Subsequent discussions between USDA officials and WJAE editors have focused on resolving these two concerns and a third concern of USDA that a reasonable limit be placed on its staff workload.

A data access policy like WJAE's forces editors to consider what they would do if an author who has consented to make data available upon request fails to do so. Our first recourse would be to use editorial persuasion. Our second recourse would be simply to include a brief statement in the Journal indicating that the author had not made data available in compliance with an earlier agreement.

So, how has the WJAE data/methodology access policy affected the workload of editors, authors, and government agencies that collect data? In private discussions, this question has been a major concern of agency officials who administer confidential government data sets. To date, this concern has been moot. WJAE has not received a single formal request for data from published articles in the past 3 years.

In Conclusion

A policy of guaranteed access to data and methodology for articles published in WJAE has not spawned a rush of requests for data. Why? Possibly, because science does not reward or encourage replication (3, p. 587):

> Thomas Kuhn (1970) emphasized that replication—however valuable in the search for knowledge—does not fit within the "puzzle-solving" paradigm which defines the reward structure in scientific research. Scientific and professional laurels are not awarded for replicating another scientist's findings. Further, a researcher undertaking a replication may be viewed as lacking imagination and creativity, or of being unable to allocate his time wisely among competing research projects. In addition, replications may be interpreted as reflecting a lack of trust in another scientist's integrity and ability, as a critique of the scientist's findings, or as a personal dispute between researchers. Finally, ambiguities and/or errors in the documentation in the original research may leave the researcher unable to distinguish between errors in the replication and in the original study. Months of effort may yield the replicater only inconclusive results regarding the validity of the original study, and thus no foundation for his future research in the area. These circumstances nurture a natural reluctance to undertake replication studies.

Some observers might argue that the lack of incentives for replication points up the irrelevance of data/methodology access policies in professional journals. I argue that it indicates the opposite. By encouraging preservation of the utilized data and estimation procedures, these policies help dismantle one important practical barrier to replication. Such policies can also improve the quality of research at the outset. Dewald, Thursby, and Anderson (3, p. 589) provide evidence "... that the existence of a requirement that authors submit to the journal their [computer] programs and data along with each manuscript would significantly reduce the frequency and magnitude of errors.... [T]he very process of authors compiling their programs and data for submission revealed to them ambiguities, errors, and oversights which otherwise would be undetected." They convincingly argue that authors can more efficiently and accurately assemble their data and methodology when they submit an article than they can several months or years later. Indeed, approximately a third of the authors in their sample had "lost or destroyed" their data for articles submitted as recently as 6 months in the past. JMCB and JAE ask authors to submit data sets and computer programs to the editorial office. This is more stringent than the WJAE policy which requires authors to keep data to satisfy potential requests for up to 5 years.

Dewald, Thursby, and Anderson also reported that a journal can provide a cost-effective central storage location for data sets and programs. JMCB reports no unreasonable storage or logistics problem with its policy. The JMCB data bank, furthermore, has been used in graduate classes where students have been assigned to replicate the results of published studies. Using a journal as a third party for data access mitigates possible personal fears that might preclude a researcher from asking a published author for original data.

Professional journals have a role in fostering access to estimation methodology and data used in published articles. Given the current incentive structure, neither authors nor readers have much motivation to facilitate

replications or to undertake them. If professional journals do not foster an environment conducive to scientific replication, who will?

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Agriculture and Water Quality: International Perspectives. *Edited by John B. Braden and Stephen B. Lovejoy. Boulder, CO: Lynne Reinner Publishers, 1990, 224 pages, $25.*

Reviewed by Stephen R. Crutchfield

How does agriculture affect water quality? In this book, the question is addressed but unresolved. The 1989 conference that produced this doggedly serious but reservedly informative book brought together some prominent researchers in the field to discuss possible solutions to the water quality problem, to present experiences with alternative agricultural policies to prevent water pollution at home and abroad, and to consider the effect of these policies on international competitiveness in agricultural products.

One of the difficulties with books that are proceedings of professional meetings is that they are often less cohesive and unified in theme and scope than books written to stand on their own. The editors (who also helped organize the conference) assembled some interesting papers. Do the papers, when collected as a book, convey the same information to the reader as the conference did to the participants? Does the book serve a useful purpose for interested readers in presenting a well-rounded overview of water quality issues? My answer to both questions is a qualified "yes."

The papers are generally descriptive in nature. In what is becoming a rarity in modern economics, no mathematical models appear. The chapter, "Pollution Control by Incentive Policy," by Sergerson, is an example of this. The issue of whether to control externalities by regulation of quantities or through application of taxes is an old one. Many detailed mathematical treatments of this issue have been published. Sergerson avoids math for a simpler analytic approach. A descriptive approach using commonly understood economic principles illustrates the differences between taxing agricultural externalities or output, providing incentives for adoption of alternative farm management practices, and applying *ex-ante* incentives through liability rules to prevent agricultural pollution. The other papers in this collection likewise eschew mathematics. The economist looking for new techniques in modeling agricultural externalities will be disappointed. Readers who look for a more common-sense approach to understanding the issues based on a strong economic framework will find the flavor and tone of these papers refreshing.

The best part of the book is the beginning, assessing water quality issues and comparing the use of incentives with the use of regulations for controlling agricultural water pollution. Any economist with only a basic familiarity with these issues would finish this section with a much better understanding of how agriculture affects water quality and which policy tools solve water quality problems. Less satisfactory is the second part of the book, which consists of five papers relating policy experiences in Sweden, Denmark, Australia, the United States in general, and California specifically. The quality of the papers is uneven: Reichelderfer's discussion of U.S. Federal policy is outstanding, and the two papers on European water quality issues present a good contrast to the U.S. experience. However, the discussion of California's Proposition 65 by Hefland and Archibald contains little economics and is unrelated to water quality. Musgrave's paper on salinity problems in Australia is more of a political science discussion of institutional arrangements than an economic analysis of water quality issues. The book's third part, with papers on international considerations by Runge and by Young, is more cohesive, and makes some interesting points regarding environmental protection statutes as substitutes for trade barriers.

The uneven style and spotty economic content of some of the papers in this book are disappointing but fairly characteristic of proceedings publications. The editors should have taken a stronger hand in guiding the authors and shaping their contributions, rather than simply reproducing the papers as they were presented at the conference. Additional editing and revision would have given the book a greater sense of cohesion and unity of style. Some papers are too long, and others fail to blend with the subject material.

Even so, I recommend the book. Despite the flaws, it still contains much interesting and useful material. I see two types of readers who may find this book a worthy addition to their collections. First, the agricultural economist interested in a general overview of the water quality problem would find some background material and summaries of options for addressing the agriculture/water quality dilemmas. Second, the environmental scientist can gain an understanding of the economic factors that lead agricultural production to harm the water supply.

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Boldly Going Where Others Have Gone Before

Forest Resource Economics and Policy Research: Strategic Directions for the Future. *Edited by Paul V. Ellefson. Boulder CO: Westview Press, 1989, 403 pages, $59.*

Reviewed by Jeffrey C. Stier

Forest economists have not yet reached the stage of diminishing returns in identifying topics for further research. At least that is the impression one gets from the more than 100 "strategic directions" and more than 300 individual research topics identified by the volume's 31 authors in this, the fourth such review of the field over the past 50 years and the third since 1953. The editor makes no attempt to attach priorities to the individual research areas identified, and the 20 research directions that are listed in the concluding chapter are broadly defined. Consequently, the book presents a large and varied research menu rather than a set of "strategic directions" for future research. Readers will have to decide for themselves the relative importance of the individual topics, but perhaps that is as it should be.

Since the beginning of this century, the United States has gone from a Nation in which the forest industry exploited a mature timber resource, and for which the main determinants of timber supply were the costs of harvesting and transportation, to a situation in which timber must be grown as a crop with all the associated production costs. This transition has increased the need for more efficient timber production. However, the past three decades have also witnessed an enormous growth in the public's demand for noncommodity outputs from forests, ranging all the way from traditional forms of recreation to the more recent emphasis on protection of biodiversity. And, superimposed on these changes has been the increasing importance of international economic linkages. All of these changes have resulted in greater demand for forest economics and policy research.

The first part of the book examines the historical, institutional, and investment context of forest economics and policy research. Ellefson's chapter examines the research infrastructure in terms of numbers of scientists and projects, and explores the changes in level and allocation of investment in research over time and by agency. The discussion of changes in funding levels, however, is somewhat difficult to follow because Ellefson never states explicitly whether the data reported in the tables are in constant or current dollars. A helpful strategy would have included the discussion of what agencies conduct forestry research and how such research is coordinated at the national level before launching into the details of the research infrastructure. Instead, the reader is enlightened two chapters later, and the intervening chapter on research evaluation and planning seems totally out of context. (It is interesting to note that Larry Tombaugh's call for competitive funding of forest economics and policy research is echoed in the National Research Council's recent report *Forestry Research: A Mandate for Change* (National Academy Press, Washington, DC, 1990).)

The second part of the book consists of 20 chapters, each of which deals with a specific area within forestry. The chapter on institutional arrangements for directing the use and management of forests by Perry Hagenstein should especially interest resource economists. He calls attention to the long-term changes in the nature of property rights and the need for the research community to keep both public and private landowners abreast of the implications of such changes. Forest economists have given only modest attention to evaluation of existing institutions and even less to anticipatory research on the development of new and imaginative institutional alternatives. Yet, the future will likely be characterized by increased emphasis on management of forests as ecosystems, by greater recognition of the interrelationships between forest and agricultural lands, and by incorporation of principles of landscape management into resource conservation and development policies. The marginal value of research in this area would seem to be very high indeed.

An institutional factor that has long irked foresters is the *ad valorem* property tax. Objections to the property tax go back to 1819, when Governor Walcott of Connecticut pointed out that owners of forestland must pay the tax for many years but receive income only when they harvest trees. In the early part of this century, F.R. Fairchild's theoretical analysis confirmed the bias of the property tax against capital-intensive, long-maturity enterprises like forestry. The argument has become so well entrenched in the forestry community that virtually every State has an alternative to *ad valorem* taxation of forestlands. Yet, as David Klemperer points out in his chapter on taxes and forestry, there has been almost no empirical research to determine the effectiveness of these alternative programs in promoting sound forestry practices, the administrative costs they impose on local and State governments, or the distribution of benefits.

The situation is much the same for research on the income tax. The nature of timber production is such that many costs must be paid well in advance of the

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receipt of income. Revenue from timber sales can qualify for capital gains treatment, but the Tax Reform Act of 1986 removed the principal advantage of such treatment. Advocates of capital gains for timber sale income noted that their arguments were damaged severely by the absence of any credible empirical research on the impact of the capital gains on forest management decisions. Past research has typically been based on analytical models or simulation exercises. But as Klemperer points out, if research is to have policy relevance, there is a strong need to document empirically the effects of income tax provisions on forest management decisions.

The chapter on forecasting demand and supply of forest resources, products, and services focuses almost exclusively on timber. It provides a good overview of recent equilibrium market models developed in the United States and a brief discussion of work in other countries and by international agencies. This is one of the few instances in which forest economics and policy research outside the United States is recognized. The discussion of the market models is surprisingly frank. For example, the author, Clark Row, readily admits that data deficiencies are frequently overcome through the use of "expert judgment" and that model validation is often *ad hoc* and judgmental, frequently being based largely upon the credibility of the projected scenarios. Data are even more limiting at the subregional level. Yet, as Henry Webster and Daniel Chappelle discuss in their chapter on community and regional economic growth and development, such data are crucial for formulation of rational policies.

Readers with a careful eye and the patience to wade through the entire book will detect a number of interconnecting threads that could lead to some quite interesting research questions. For example, Jay O'Laughlin notes in his chapter on industrial organization that changes in the ownership of firms can influence the structure and performance of the forest products industry. But, might not changes in ownership also have implications for community stability, as well as for the pattern of forest-based regional economic development, and even for international trade flows? O'Laughlin does not raise these questions. Yet, they have rarely been addressed by past research, and answers to them would seem to be important in the formulation of economic development strategies and antitrust policies.

The book has its shortcomings, including an annoying number of grammatical errors. The organization and coverage of topics are uneven. For example, four chapters deal directly with timber, that is, with production and harvesting of wood fiber, management and protection against fire, insects, and diseases, and marketing of forest products. However, they are not grouped together. Production and valuation of recreation and water are each accorded a chapter, but neither wildlife nor range is given separate treatment. A chapter is devoted to nonindustrial forests but none to other ownerships.

The main audience for this book will be the community of forest economics and policy researchers, but I doubt that many will read it from cover to cover. The most

The chapters include: (1) "Development and Accomplishments of Research Programs" by Henry J. Vaux and H.R. Josephson; (2) "Problem Orientation and Investments in Research Programs" by Paul V. Ellefson; (3) "Impact Evaluation and Planning of Research Programs" by David N. Bengston; (4) "Organizational Involvement and Management of Research Programs" by Larry W. Tombaugh; (5) "Institutional Arrangements Directing Use and Management of Forests" by Perry R. Hagenstein; (6) "Economic Structure and Performance of Forest-Based Industries" by Jay O'Laughlin; (7) "Development, Dissemination, and Adoption of New Technology" by Allen L. Lundgren; (8) "Forecasting Demand and Supply of Forest Resources, Products, and Services" by Clark Row; (9) "Social and Economic Growth of Developing Nations" by Hans M. Gregersen and Jan G. Laarman; (10) "International Trade in Forest and Related Products" by Thomas R. Waggener; (11) "Wood Fiber Production" by J. Michael Vasievich; (12) "Timber Harvesting" by Frederick W. Cubbage; (13) "Production and Valuation of Forest and Wildland Recreation" by George L. Peterson and Thomas C. Brown; (14) "Policy Development and Program Administration" by Paul V. Ellefson and James R. Lyons; (15) "Resource Assessment, Information Management, and Communications Technology" by Thomas E. Hamilton; (16) "Forestry Sector Environmental Effects" by J.E. de Steiguer; (17) "Community and Regional Economic Growth and Development" by Henry H. Webster and Daniel E. Chappelle; (18) "Taxation of Forest Products and Forest Resources" by W. David Klemperer; (19) "Distribution and Marketing of Forest Resource Products" by William G. Luppold and Gilbert P. Dempsey; (20) "Forest Resources Law and Legal Processes" by Benjamin V. Dall; (21) "Management of Fire in Forested Environments" by Thomas J. Mills; (22) "Management of Insects and Diseases in Forested Environments" by Lloyd C. Irland; (23) "Structure and Performance of Nonindustrial Private Forests" by William B. Kurtz; (24) "Production and Valuation of Water from Forested Watersheds" by K. William Easter; (25) "Challenges and Agendas for Forest Resource Economics and Policy Research in the Coming Decade" by H. Fred Kaiser, Richard L. Porterfield, and Paul V. Ellefson.

useful approach for current researchers and for those outside this community would probably be to focus on selected chapters that cover topics of special interest. The book nevertheless serves as a useful fourth benchmark in the evolution of forest economics and policy research.

From the winter of 1989 to the spring of 1991, the Journal published a series of essays on the social sciences in agriculture, particularly agricultural economics. Some essayists lauded the performance of the profession, others criticized. All presented viewpoints subject to challenge. We decided to pull the series together under a single cover and explain its significance.

The argument for self examination, if for no other reason, should be made on the grounds of fairness. If agricultural economists can examine the efficiency and effectiveness of the food system, why not ask about the efficiency and effectiveness of agricultural economics?

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The Failure of Economics in Environmental Management

Public Policies for Environmental Protection. *Edited by Paul R. Portney. Washington, DC: Resources for the Future, 1990, 323 pages, $25 (hardcover), $9.95 (paperback).*

Reviewed by James A. Tobey

Economics has not had a big impact on the design of environmental policy. This is somewhat ironic since the problem of pollution as the archetype market failure has been known for so long. In reading this book, one might suspect that the modest effect of economics on the design of environmental policy can be partly attributed to the fact that economic analysis relies on the neoclassical framework, which does not give institutional and political considerations a large role. For whatever reason, as Paul Portney observes, environmental economists "... are perceived as being blind (or at least myopic) to the real-world problems that would arise in implementing solutions that look attractive in theory." This collection of contributed chapters, by a group of well-known professional economists, attempts to allay this perception by analyzing environmental policymaking from an institutional perspective and by suggesting realistic opportunities for increasing the efficiency of pollution control programs.

The text does not require prior knowledge of economics. Rather, it is directed toward a wide audience interested in the administration of U.S. environmental protection policies. The text is also uncluttered by references, but those who seek to explore issues in more detail will find the notes at the end of each chapter useful. Also benefiting from the text will be academic environmental economists who are experts in the intricacies of minimizing the costs of pollution control in theory but who are not well versed in the difficult linkages of environmental legislation and administration.

The book follows Portney's 1977 effort, *Current Issues in U.S. Environmental Policy*. The focus of environmental policy has changed since that book was released, with more concern now on hazardous wastes and toxic substances than on the now well-known problems of air and water quality. Portney's recent work comes at a timely juncture to step back and evaluate the historical performance of environmental legislation, much of which was introduced in the early 1970's.

The chapters target all the main areas of pollution policy: air, water, hazardous wastes, and toxic substances. In addition, Clifford Russell discusses monitoring and enforcement problems, areas of increasing importance since most firms have made the required initial capital investments for pollution control instruments but many may not be operating them. The chapters follow a consistent format. They briefly explore the evolution of current policy and the state of the environmental problem, discuss implementation mechanisms of current policies and sometimes offer some sense of the costs and benefits of policy, and make suggestions for increasing program efficacy. These suggestions are bounded by the constraints of present environmental legislation.

The text makes abundantly clear that the constraints of legislation are considerable and frequently politically driven. Portney suggests that both the New Source Performance Standards of the Clean Air Act and the Toxic Substances Control Act treat new and old pollution sources differently, introducing incentives that make environmental management more difficult. We learn that in order to get new environmental legislation passed the applecart must remain upright. Politics and income distribution issues are also behind the restriction that does not allow newly built electric powerplants to reduce sulfur dioxide emissions by switching from high-sulfur to low-sulfur coal. Fuel switching would endanger the jobs of a small number of high-sulfur coal miners, but it would also produce tremendous cost savings. Portney's point is not that all environmental laws are designed to advance hidden agendas, but rather that politics often makes environmental policy unnecessarily complex. Awareness of the less obvious consequences of laws and regulations may help one understand why a particular policy took the shape it did.

Environmental policy in the United States is now so developed and complex that it is a significant challenge to treat all the environmental media and issues in a single volume. The book should be praised for covering so much ground so succinctly. However, I could not help but notice the limited attention devoted to agricultural nonpoint source pollution problems (management of toxic substances, including pesticides) although the Federal Insecticide, Fungicide, and Rodenticide Act is discussed in detail). Portney suggests that water pollution from farms and other nonpoint sources has been overlooked altogether because of the political power of the parties that would be affected by tighter controls. While in the past this may be true, I think many would argue that ground water, surface water, and food quality issues associated with agriculture now rank as primary areas of U.S. environmental concern.

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Another policy area that I would like to have seen developed more is the role of environmental federalism in environmental policy. Environmental federalism is generally viewed favorably by economists. Management of local environmental problems is best introduced at the State or local level where the stringency of pollution control can be set according to local environmental preferences and costs.[1] Portney recognizes in the concluding chapter that local pollution control is one of three important trends that is likely to influence the direction of environmental policy changes, but otherwise the book does not address the issue.

What is the prognosis for environmental management and the role of economics? Portney answers this question in the concluding chapter. Both forecasts are hardly optimistic. Two elements are worth noting with respect to environmental management. First, the record on environmental improvements is poor. Only in the case of air quality can widespread improvements be shown. There is no clear indication that water quality has improved. Progress under both hazardous waste and toxic substances control has been modest and environmental enforcement efforts have been weak at best. Second, Portney suggests an increasing trend toward reducing the flexibility previously granted regulatory officials, an unwelcome development because an important lesson of the book is that flexibility and discretion are key to effective environmental management, especially now. Environmental problems, Portney observes, are too diverse and complex for the use of uniform, across-the-board solutions.

The news for the role of economics is equally discouraging. Several recent environmental laws have moved away from allowing economic considerations in the determination and achievement of environmental standards. The 1980 Superfund Act, the 1984 amendments to the Resource Conservation and Recovery Act, and the 1986 amendments to Superfund are examples. With the exception of emissions trading under the "bubble" policy, the role of economics in the design of environmental policy to achieve environmental quality standards does not appear to have significantly increased since the 1970's. Clearly, much work still lies ahead. Perhaps the insights provided by this book and others like it will improve environmental policymaking by, among other things, showing the important role economics can play in environmental management.

The chapters include: (1) "Introduction" by Paul Portney; (2) "The Evolution of Federal Regulation" by Paul Portney; (3) "Air Pollution Policy" by Paul Portney; (4) "Water Pollution Policy" by Myrick Freeman; (5) "Hazardous Wastes" by Roger Dower; (6) "Toxic Substances Policy" by Michael Shapiro; (7) "Monitoring and Enforcement" by Clifford Russell; (8) "Overall Assessment and Future Directions" by Paul Portney.

[1]W. Baumol and W. Oates, *The Theory of Environmental Policy*, second edition, Cambridge University Press, pp. 284-96, 1988.

Developments in Land Information Management. Edited by R.E. Dahlberg, J.D. McLaughlin, and B.J. Niemann, Jr. Washington, DC: Institute for Land Information, 1989, 184 pages, $36 (paperback).

Reviewed by Norman Leppert

Dahlberg and his fellow editors have gathered a well-chosen collection of 14 papers on land information systems and related topics selected, with one exception, from 1984-88 symposia, conferences, journals, and reports. The articles, which are international in scope, include broadly descriptive papers and discussions on current issues, trends, applications, and conceptual frameworks. Included are various perspectives on the scope and definitions of land information systems (LIS) and related geographical information systems (GIS) plus a historical overview of the multipurpose cadastre. Looking at land-use management information through the eye of the user is a major strength of the collection. The articles are aimed in large part at individuals in disciplines that have traditionally collected and used land data, such as surveyors, cartographers, geographers, scientists, foresters, and appraisers, but other land-use specialists, such as planners, economists, records managers, and attorneys, will find the discussions very useful.

Economists who utilize LIS techniques will have the ability and advantage of computers to develop the analytical models and tools needed for effectively managing large volumes of land-related data that have not been readily available or easily analyzed in the past. Information compiled from layers of resource, socioeconomic, and environmental data is being used to develop decisionmaking models. Proper utilization and integration of these data and information can be used in developing policies, reducing duplication and costs, and will result in increased economies and efficiencies for allocating limited resources for the private and public sectors. Now, environmental problems add another dimension to the land component of economic analysis.

Land information systems are constructed from layers of spatial data, such as soils, vegetation, natural features, and proper boundaries. Visualize a "layer cake," with each layer a specific digital data base. Cutting a slice of the cake provides a look at the cross-section and the relationship of the specific layers and composition of the cake. The different layers, or data bases, can be analyzed by computers to show status, changes, and trends. Complex interrelationships and interactions may be tested, opinions clarified, and solutions delineated. This is a greatly simplified explanation but one that may be helpful to individuals who do not often use land-related data.

Even though the individual articles are informative, the novice could face some difficulties in digesting them. First, a major criticism: there are few distinctions between LIS and GIS definitions. While the newness of the topic has kept terminology from becoming standardized, some of the articles imply that the two are synonymous. Definitions are evolving as the systems evolve and the LIS and GIS concepts share many similarities. If there is a distinction between LIS and GIS, it should be noted, and early on. D.F. Marble's article, "Geographic Information Systems and Land Information Systems: Differences and Similarities," appears midway through the volume. A better choice would have had it as a lead article. Or, the editors might have included a paragraph in the introduction that explicitly defines an LIS and distinguishes it from a GIS.

Dahlberg contends that managing information for land and land-related topics is an urgent task, a challenge for all levels of governments. He states that the land information management communities and the political leadership at the State levels are realizing land information is a corporate and community resource requiring innovative management of infrastructural development. The era of relying on the "best available information" is rapidly vanishing. Dahlberg believes that, as user information requirements are subjected to more formal reviews, data standards will become better documented and data base development projects will be accelerated. Among the cautionary lessons to be drawn from this collection is that software must be maintainable and alterable to accommodate improved or new hardware and software and must also be reliable enough to detect and recover from errors. Technical requirements and accuracy standards for multipurpose GIS and LIS software must be flexible enough that new applications are unaffected and related applications are only slightly affected. Failure to meet accuracy standards can lead to a lack of control and inaccuracy in the system.

The article by McLaughlin and Nichols is an excellent overview of "spatial information systems in which the fundamental structure for collecting, storing, and retrieving information is the cadastral parcel or proprietary land unit, ownership records (titles)" (p.35). A multipurpose LIS with an academic emphasis is described in "Results of the Dane County Land Records Project," which "investigated means to improve data input efficiency through scanners, satellite

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geopositioning, and remote sensing imagery" (p. 55). W.E. Huxhold describes in practical terms how the City of Milwaukee is using GIS (LIS) "to improve municipal operations, management, planning and policy-making activities." Among the applications noted are property tax delinquencies, liquor licenses, and inspector workload balancing.

Two articles, one by I.P. Williamson, the other by B. Humphries, review recent Australian experiences in implementing LIS, with the latter serving as lead article for the volume. Key to Australian progress has been the recognition at national, state, and local levels of the need to integrate resource, environmental, and socioeconomic data into parcel-based information systems and, no less important, the development of overall "strategies" to guide LIS activity.

Virtually all the articles emphasize the importance of data. But, all too often, amassing the data even from existing records and storing them in the computer, are major obstacles. For example, P.L. Croswell states that map accuracy is important for two reasons: it determines the way in which the map can be used, and there is a cost associated with map maintenance which increases as the accuracy level is raised. Effective data acquisition and management effort are the chief requirements for understanding how the system will be used and which data will be required to make the system function.

The advice offered by the authors of the various articles: make sure that there is a commitment to carry out the project, especially funding for a long-term effort; lay the groundwork for cooperation between the various land data collectors and users; and adapt technology to serve the existing organizational and institutional structures.

The articles are readable and frequently include explanatory graphics. The basic level of exposition is intermediate. However, the casual reader or beginner will find the collection an excellent overview and introductory text. Individuals who have some knowledge of LIS will find these articles of general interest in their confirmation of issues and trends already observed. At the least, economists who are attentive will gain an awareness of analytical tools and procedures that will be increasingly relevant in analyses related to natural resource and environmental problems, especially trends in allocation of resources, public funding, and social concerns.

The papers include: (1) "The Crisis in Land Management" by B. Humphries; (2) "Modernizing Land Information Systems for City Planning and Management: Problems and Opportunities" by W.E. Huxhold; (3) "Introduction to Need for A Multipurpose Cadastre" by the National Research Council; (4) "Parcel-Based Land Information Systems" by J.D. McLaughlin and S.E. Nichols; (5) "Results of the Dane County Land Records Project" by B.J. Niemann, Jr., D.F. Sullivan, S.J. Ventura, N.R. Christman, A.P. Vonderohe, D.F. Mezera, and D.D. Moyer; (6) "Trends in Land Information System Administration in Australia" by I.P. Williamson; (7) "Geographic Information Systems and Land Information Systems: Differences and Similarities" by D.F. Marble; (8) "Findings Regarding a Conceptual Model of a Municipal Data Base and Implications for Software Design" by J. Dangermond and C. Freeman; (9) "Map Accuracy: What is it, Who Needs it, and How Much is Enough" by P.L. Croswell; (10) "User Requirements in Land Information System Design—Some Research Issues" by P. Zwart; (11) "The TIGER System: Six Years to Success" by R.W. Marx; (12) "Technical Requirements and Standards for a Multipurpose Geographical Data System" by M.S. White, Jr.; (13) "Modeling Location for Cadastral Maps Using an Object-Oriented Computer Language" by D. Kjerne; (14) "Requirements for Database Management Systems for Large Spatial Databases" by A.U. Frank.

Two Guides

A Community Researcher's Guide to Rural Data. *By Priscilla Salant. Washington, DC: Island Press, 1990, 93 pages, $19.95 (paperback).*

and

Guide to Economic Indicators. *By Norman Frumkin. Armon, New York: M.E. Sharpe, Inc., 1990, 242 pages, $15.95 (hardback).*

Reviewed by Edward Reinsel

Here are two helpful guides for users of data and economic indicators. Salant's handbook "acquaints researchers with data that they can use to describe and better understand rural communities." Frumkin's is "a practical book for obtaining information quickly about the main characteristics of economic indicators." Both guides effectively serve the purposes for which they were written.

Salant's five-chapter manual begins with a few basic data concepts followed by an overview of data sources. Her primary focus is on secondary data from the Federal Government. Census data receive the most attention. The Census of Population and Housing is viewed as the core "of our knowledge about rural communities." Readers who are unfamiliar with rural data will certainly find the handbook to be informative. Those who already understand the Census of Population and Housing may find that they can spend their time more profitably in other ways.

Besides pointing the reader toward sources of data on rural populations, resources, economies, and governments, Salant frames appropriate questions, adds helpful hints, and identifies cautions worth observing. Nonmetro counties are classified according to Economic Research Service county types. Throughout the manual, six sample counties are the basis for her demonstration of how the various data sources can be used.

To Salant rural does not mean farm. It takes her only slightly more than one page to cover the vast amount of farm-related data from the Census of Agriculture, the National Agricultural Statistics Service, and the Economic Research Service. The scant treatment of farm data limits the manual's usefulness for analysts who have a special interest in the farm sector. But, they were not the intended audience.

Salant writes from the perspective of one who is familiar with and has used rural data. What she has to say is practical and can be easily grasped. A quick reference guide at the front, a table of contents, several pages of references, a glossary, five appendixes, a rather detailed index, and a list of acronyms are there to assist users. As a former analyst with ERS, she shows the organization and lists major activities of ERS's Agriculture and Rural Economy Division, the primary unit in the Federal Government that studies and reports on rural communities and their economies.

Frumkin uses a standard format to describe more than 50 economic indicators. His background in government statistics should be helpful to almost anyone with an interest in how the U.S. economy works. An introduction explains a few statistical concepts. It also describes uses for economic indicators, their interpretation, and their evaluation. Like Salant, he writes so that little background is needed. Because the presentations are listed in eight general topics and the indicators are presented in alphabetic order, users can quickly find what they need.

The book is not likely to be read from cover to cover. It is not for the highly sophisticated user who wants to delve deeply into the details of how any given indicator is produced. Still, it will often be taken off the reference shelf for review or to gain an understanding of a particular indicator. The book is mostly limited to indicators that help in understanding the general economy. Frumkin makes no distinction between the rural and urban economies.

Analysts differ in the way they view economic indicators. But, not many people who are familiar with the range of indicators available would agree with Frumkin's choice of the conceptually obsolete farm parity ratio as the sole indicator for the agricultural and rural economies. That choice betrays a lack of interest in or limited knowledge of the large number of economic indicators available on food and agriculture.

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Keying Economic Development to Improved Infrastructure

Developmental Impact of Rural Infrastructure in Bangladesh. *Raisuddin Ahmed and Mahabub Hossain. International Food Policy Research Institute in collaboration with the Bangladesh Institute of Development Studies, Washington, DC, 1990, 150 pages. Free.*

Reviewed by Richard F. Nehring

It seems obvious that an improved infrastructure is the key to economic development and sustained gains in agricultural productivity for many countries in Latin America, Africa, and Asia. The relevant literature spans the treatise of von Thunen and the work of economists, such as Antle, Lewis, Mellor, and Ruttan. Why then do most countries fail to accord adequate priority to infrastructure development? Is it because the impact of infrastructure on agricultural development is not well quantified and, hence, poorly understood? Ahmed and Hossain say, yes, and the allocation of public expenditures to infrastructure development is niggardly and inefficient. They argue persuasively, taking the inquiry of the impact of infrastructure on agricultural productivity a step forward. By developing a thorough empirical case study, they assess the effect of rural infrastructure on farm output, employment, income, consumption, savings and investment, and market and social development.

Their basic analysis relies primarily on 1982 survey data from 16 villages which were part of a 129-village survey, representing 640 household observations. From the myriad infrastructural elements that influence development and productivity, the authors constructed a single quantitative index. The index is a composite of a village's access to primary markets, secondary markets, secondary schools for boys, banks, bus stops, and local political offices. This procedure for measuring the degree of infrastructure is based on a method developed for ranking countries by levels of economic development. The effects of infrastructure are then measured by comparing developed and underdeveloped villages by using the infrastructure index or individual elements of the index in regression equations.

The paradigm of two well-defined categories promotes a tractable analysis. The richness of the data set allows the authors to go into considerable detail to explain the infrastructure of this Bangladeshi case. Their results characterize the local situation and justify reliance on two development categories in their subsequent analysis.

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The authors' chapter on infrastructure and agricultural production traces how infrastructure affects price variation, differences in management use, efficiency of resource use, and level of production. Comparing data for the three most developed villages and the three least developed, the study finds that the price paid to farmers for paddy rice is about the same in all of the villages, but fertilizer prices are 14 percent lower and labor costs 12 percent higher in the developed villages. Moreover, 105 percent more farmland is irrigated, 71 percent more is sown with high-yielding varieties (HYV's), and use of fertilizer is 92 percent higher in developed villages. These differences in adoption of new technology and prices had only a small effect on the total use of labor, but they substantially influenced the composition of labor use. The combined effects of wider and more efficient use of new technology as a result of infrastructure development is estimated to have raised agricultural production in developed areas as much as 32 percent.

Employing a profit function, the authors use the sample of farms to test the hypothesis that infrastructure contributes to agricultural productivity. The Cobb-Douglas profit function is specified as a function of two variable inputs (labor and fertilizer), two fixed inputs (capital and land), and a dummy variable (which has a value of one for households operating in infrastructurally developed villages and zero for others). The value of the coefficient of infrastructure is positive and statistically highly significant, suggesting that farms in developed areas are more technically efficient than farms in underdeveloped areas. The authors argue that this may be the result of wider availability of irrigation facilities, higher rates of adoption of HYV's of rice, and better management in the developed villages. I suggest, however, that these results must be interpreted with caution in that technical efficiency comparisons should involve comparisons on the same production function. Ideally, one would, for example, compare irrigated winter rice production, which depends on the diffusion of new technologies in both developed and underdeveloped villages.

The values of coefficients on labor and fertilizer are statistically highly significant. This implies that farmers in Bangladesh adjust output and input levels in response to price changes. The results imply an output price elasticity of 0.56 and a price elasticity of demand for fertilizer of -1.12.

The study's important results on irrigation deserve close scrutiny because of their implications for public investment versus private investment. The authors extended the paradigm based on the 1982 survey and analyzed irrigation data on a 1988 census of 1,609 vil-

lages. They divided the data into three groups in terms of access to transportation: easy, moderate, and difficult. They found that installation of small-scale irrigation tubewells was much higher in easy-access areas, that tubewells were better maintained in these areas, and that electrification of tubewells, which cuts operating costs by more than half, was seven times more extensive. Twelve percent of villages in the easy-access groups had no shallow tubewells, while 29 percent did not have shallow tubewells in the difficult access group. And, 60 percent in the easy-access group had no deep tubewells, while 70 percent had deep tubewells in the difficult-access group. Deep tubewells are generally installed by public agencies in Bangladesh because of relatively high overhead. Shallow tubewells are left to private initiative. The different rate of diffusion of deep and shallow tubewells in the three groups of villages supports the hypothesis that some public measures, though expensive, can help overcome constraints imposed by infrastructural backwardness.

This implies that a policy to encourage small-scale irrigation diffusion through the private sector, a policy now favored by aid donors to Bangladesh, is most likely to enjoy success where infrastructure is developed.

Estimations based on the most and least developed villages indicate that infrastructure improvement causes household income to rise by about a third. As opportunities for off-farm employment are generated, households in developed villages substitute hired labor for self-employed farm labor. This process tends to raise wages and significantly benefits lower income groups. While the development process in Bangladesh and other underdeveloped countries may increase the income of rich households at a faster rate than that of poor households, the increase in the absolute level of income of the poor is significant.

Few results are surprising in the remaining chapters, which examine how infrastructure development changes consumption, savings and investment, and social development. Households in developed areas spend a larger share of incremental income on noncereal foods, commodities other than food, and services. And, the supply of such commodities to meet increased demand is facilitated by lower marketing costs, improved operation of input and output markets, and improved linkages with other sectors. Infrastructure development encourages savings and investment indirectly through increases in income, with 14 percent higher investments per household in developed villages. One result is surprising. Development of infrastructure does not appear to improve literacy. Rather, literacy appears to be explained by the size of landholding and gender.

Although the authors characterize the data as pertaining to 16 villages in various parts of Bangladesh, the reader is left to speculate on how representative are the data of agricultural production and rural development in Bangladesh. Even though Bangladesh is a small country, the production base is diverse, with food-surplus districts in the northwest and food-deficit districts in the south and east. The potential for small-scale irrigation also differs sharply, with, for example, relatively little scope for deep tubewells in the northwest. And, the potential for expansion into winter rice and wheat, which depends on the diffusion of new technologies, differs by region.

The book is generally well organized, and results are carefully reasoned and interpreted. The statistics and economics are sound. Production and consumption issues could have been more completely investigated by pursuing a household production function approach and assuming that farm household's utility and profit maximization decisions were not likely to be independent. Nonetheless, the analysis of Ahmed and Hossain explores many important development issues in Bangladesh and will undoubtedly serve as a model for other analyses in Latin America, Africa, and Asia.

The effects of infrastructure on agricultural production and rural development as described in this book are definitive. The study's results serve to encourage efforts that identify potential infrastructure projects and to more rigorously rank benefit-cost ratios and fund them accordingly. The authors suggest that the private initiative now being encouraged by the donor community may benefit from a higher priority on selected public expenditures in infrastructure.

The Humane Economy: Populism, Capitalism, and Democracy. *By Norman Pollack. New Brunswick NJ: Rutgers University Press, 1990, 229 pages, $40 (hardcover).*

Reviewed by Gene Wunderlich

One hundred years ago the Populist movement achieved its political zenith in forming the Populist Party. Officially the "Peoples Party of the United States of America," the Populist Party was founded in Cincinnati, Ohio, by discontented farmers who saw the liberating promise of capitalism broken by monopolies in transportation and finance. In 1892, the Populist Party nominated and ran James Weaver of Iowa for president and James Field of Virginia for vice president. Although the party garnered 22 electoral votes in the election, its real achievements were its challenge to the unrestricted economics of *laissez faire* and a platform that later became mainstream policy.

Norman Pollack, a much published scholar of Populism in America, relates the movement to the economics of capitalism. In other books, he has addressed political, legal, and moral issues inherent in the movement. In *The Humane Economy*, he illuminates the role of Populism in economic policy, showing how Populist policies may have saved capitalism in America from destruction by its own excesses. Populism may well be one of the most notable contributions of America's farmers to the Nation's economic policy.

In reading Pollack, it is helpful to recall the economic conditions of America in the late 1800's. Agriculturally, the country was in the final stages of settlement, still experiencing the growing pains of expanding production and marketing. Railroads, themselves in financial and organizational turmoil, were key to marketing the products of a commercial agriculture. The Panic of 1873 reflected a general condition of growth, outrunning the capacity of economic and financial institutions. To accommodate the rapid capitalization of the economy, new instruments of centralization and power arose. The first trust, Standard Oil, was formed by John D. Rockefeller in 1879. Farmers, at the bottom of an economic pyramid topped by finance and transportation, felt exploited and denied the fruits of the free enterprise system.

The Populist perspective of property is worthy of review even in the context of many of today's economic issues. In their time, Populists supplied a needed re-examination of the assumption of unrestricted acquisition of property and unlimited exercise of property rights. Lorenzo Lewelling, representing the western branch of Populism, saw human rights and property rights as sometimes conflicting. The natural rights doctrine as applied to property was limited. Government, as the instrument of welfare in a democratic society, might have to restrict property. Both Lewelling and Frank Doster argued that the role of government was to protect the individual from the oppressions of social Darwinism inherent in an unrestrained free market system.

The core of Pollack's analysis is his comparison of the political economy of Adam Smith with that of the Populists. More precisely, his comparison is of Smithian and Populist economics as perceived by selected spokesmen or by himself. Over a broad range of principles, the liberal emphasis on individual autonomy ("internal economic activation") was common to both the Smithian and Populist positions. Populists were skeptical, however, of the self-correction mechanisms of the 18th century model. Pollack quotes from Henry Lloyd: "Liberty produces wealth, and wealth destroys liberty." (p. 131). Competition is desirable as an engine of efficiency, but competition fails when it leads to restricting combinations.

The Populist position rested heavily on independence, individual initiative, and private property to stimulate development in the capitalist system. The Populist position did not oppose capitalism but encouraged its competitive features. The role of government was not to replace private initiative but to see that it could function in the widest possible arena. Pollack writes: "Armed with the benefit of a century of capitalistic practice unavailable to Smith, they [Populists] questioned the adequacy of a self-adjusting mechanism unless it was within a state framework" (p. 139).

In his interpretation of various Populist proponents and in his own synthesis, Pollack draws not directly on Adam Smith but on an undefined, but probably widely accepted, simplification of "invisible hand" economics, based on self-interest and a survival-of-the-fittest competition. The benevolence principle contained in Smith's *Theory of Moral Sentiments* is absent. In fairness to Pollack, his purpose was to contrast the apologies of ruthless capitalist expansion of the 19th century with Populist principles. Smith was merely his stalking horse, and he carefully acknowledges the anti-mercantilist context of Smith's economic perspective, a context that saw government as intruder rather than protector of economic opportunity.

Pollack relates elements of populist doctrine to the form of *laissez faire* economic policy dominant in the

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late 19th century. His model of Populist doctrine is a distillation and interpretation of leading writers and speakers of the time. In William Peffer he sees the Populist notions of the value and dignity of labor, and of corporate organization robbing the independent will of laborers to contribute to the economy. In James Weaver and others he finds that the lost independence of labor results from an imbalance of private and public forces. He quotes Scott Morgan on the effect of market structure on farmers: "Monopoly names the price of what they have to sell, and charges them what it pleases for what they are compelled to buy" (p. 20). To the economic structure arguments he adds Thomas Nugent's moral criticism of monopoly, which attacked the corrupting influence of economic concentration, yet avidly supported the sanctity of private property.

Populists emphasized the importance of independent, freely negotiated economic decisions, widely held private property, and unrestrained markets. Today, they might use the cliche, "level playing field." Their view of the role of government was one of counterforce to monopoly. Pollack draws on Davis to show that the Populist view of the necessary and proper functions of government, as declared by the Constitution, properly includes measures to assure that the free-market economy is indeed free for all to access on an equal footing. It is from views such as James Davis's that arguments for public ownership of utilities and railroads were derived.

Populism was a turning point in America's development of capitalism. It is perhaps remembered too often for slightly quirky monetary ideas, and not often enough for its trust busting and for the then-declared "socialist" ideas of a graduated income tax, parcel post, 8-hour workdays, popular election of Senators, legislative initiative and referendum, and the Australian ballot (which carries candidate names and the texts of propositions, and is given to voters at the polls), institutions we now take for granted. As we emerge from the 1980's we would do well to reread the Populist story, and from it gain insights for America's policies in the 1990's.

Anyone involved with, interested in, or affected by, agricultural economic policy or, for that matter, the future course of American capitalism and democracy, should find Pollack's book valuable.

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